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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXII, No. 9 DECEMBER, 1922 WHOLE No. 191

THE EDUCATIONAL VALUE[1] OF SCIENTIFIC TOYS

BY DR. MORRIS MEISTER, *Teachers College, Columbia University, New York City.*

Ever since Hero of ancient Greece built and played with his *toy* steam engine, the world of science has kept pace with the world of toys. The manipulative and experimental instincts of man, in seeking outlets for activity have always produced perhaps as mere by-products, devices and processes that were designed to amuse, to attract attention, to seize the fancy. But strangely enough, these little tricks of mechanical curiosity, these naive attempts to mystify one's fellow men have had a strange way of stimulating someone toward serious utilization of one of nature's forces. Thus the magnet was once a plaything; till, in a sudden burst of development, it became one of the fundamentals of modern civilization. The air-pump, the prism, the lens, the camera obscura, electrostatics, the telescope, the gyroscope, the telephone and very recently radio communication, have all done "their bit" on the vaudeville stage that science operates for the delectation of humanity.

If it but be remembered that young Isaac Newton and adolescent Faraday, as well as all the rest of that galaxy of men who have brought science to its present state, developed their love, interest, yes, and their fundamental background and experience, in play with science toys, it will not be difficult for us as teachers to pay more attention to this play activity with science that goes on amongst our boys and girls when they are outside of our classroom.

A scientist at work is in a very real sense a scientist at play. That is what our modern educational theorists mean when they speak of the identity of play and work; of motivation,

[1]Paper read before Joint Meeting of Physics, Chemistry and General Science Teachers Associations of New England, Boston, December 3, 1921, and before meeting of New Jersey State Science Teachers Association, Hoboken, May 13, 1922.

of the utilization of the inherent instincts and interests of the child; and of the project method. That concept also explains the recent tendency on the part of the educators to study carefully the after-school or extra-curriculum activities of our boys and girls. School may begin at 9 and end at 3, but it is very possible and frequently too probable that a boy's or girl's *real* education begins at school dismissal.

It is my purpose to present in this paper a brief description of a study which has been made of the different materials and activities which engage a good part of the attention of the junior high school boy—especially in his after-school time. These materials and activities are unique, because they offer the city boy, cooped up in an apartment house, the same outlet for his mechanical instincts and curiosities as the farm provides for the country boy.

Go to the toy department of the average department store or to the annual toy fair, held by the Toy Manufacturers' Association, and you will note that there are two major types of toys. The first makes its appeal to the primal sensations of color and motion. The second might be termed "toys with a meaning." In the last five years there has been a steady and rapid growth of this latter class of toy. There are four different groups of these sets or outfits, as they are called—mechanical, electrical, chemical, and sets for special purposes.

Of the mechanical sets, two are worthy of mention: The Meccano and the Erector. In the electrical field we have the St. John outfits, the Gilbert outfits, the Electro-Importing outfit and the Meccano Electrified. In the chemical field we have the Chemcraft and the Chemistry outfit. And in the last category we have outfits such as experiments with magnetism, experiments with light, experiments with heat, experiments with sound, and experiments with air and water, the Weather Bureau outfit, the mineralogy set, the radio set, the surveying outfit, the microscope and telescope set, and so on.

Each set comes in a box, neatly and attractively arranged and contains a manual describing how to perform hundreds of experiments (with reasons and principles in full) together with all the necessary equipment for performing these experiments. The average price is about four dollars and in many cases a boy can buy a one-dollar set and little by little buy the extra parts which will turn his set into a four-dollar or even a ten-dollar set.

The history of the development of Meccano is typical of a great many of these outfits and is significant educationally. The inventor is Frank Hornby of England. Born at a time when the possibilities of scientific inventions were beginning to grip the minds of men, he spent his youth and early manhood in dreaming of inventions and mechanical contrivances to do new and wonderful things. Practically all of his efforts in that direction were complete failures, but he carried with him into manhood an appreciation for this great longing of the normal boy to manipulate, to experiment, to "make things go;" so that when his own two boys arrived, it was with keen understanding that he undertook to satisfy their craving to do things.

The derrick has always proved a particularly fascinating object for boys. Hornby conceived the idea of constructing a derrick that would actually lift things, and which could be dismantled and its parts used for other purposes when the boys got tired of the derrick. The first project worked out to the satisfaction of his two boys; it was but a simple step to build with the same parts other objects of interest. Gradually the parts were standardized and perfected so as to be as interchangeable as possible. The ingenuity of his boys and his own ability to play as a boy soon developed an imposing array of different models—all built out of strips of steel, accurately and uniformly perforated, fastened by miniature brass nuts and bolts, and operated by real gears, belts and pulleys.

Dr. Hele-Shaw, professor of engineering at University College, Liverpool, recognized the educational value of Hornby's toy and assisted the latter in launching the venture commercially. A good many of the original investors in the scheme were men and women who were inspired by the Froebel doctrine and the writtings of Horace Mann, and who believed with Herbert Spencer that "Invariably children show a strong tendency to make, to build, a propensity which, if duly directed, will not only prepare the way for scientific conceptions, but will develop these powers of manipulation in which most people are so deficient."

Thus it is important to note that Meccano had its origin in educational ideals. But as with hundreds of other attempts to make money out of education, there soon arose difficulties. Hornby's toy was sold under the title, "Hornby's System of Mechanical Demonstration," in which he endeavored to provide "an economical and yet very effective series of apparatus

for demonstrating the main elementary fundaments of mechanics and mechanical science."

It is not necessary to dwell at great length on the merits of the "Hornby System." The greatest criticism and the most severe that Hornby could have received came from the boys of England. They wouldn't play with his toy. It wasn't a toy. He so completely bound up their inner urgings with his rigid procedure, he left so little for them to do, he took away from them so completely the possibility to experiment, that Meccano lost its appeal. It took Hornby about five years to realize that in his anxiety to prove that his device was "educational" he had robbed it of the spirit which had given him the original inspiration. In the parlance of our men of business, the Hornby System did not "pan out." It didn't attract. It was too "educational" to educate.

Hornby, however, persisted. Some of our modern educational theorists might have told him that teaching through play was an abuse of play, or that he was using play as a means to an end, when play should be an end in itself, or that his procedure was from general principle to application where it should be the reverse. His own analysis of the difficulty was put in this form: "The boy must have fun; if he learns anything in the process, so much the better." Since 1907 the Hornby System has been virtually extinct. In its place has come the toy that millions of boys all over the world play with.

The aims of the other sets have been conceived in just as educational a manner as was meccano. To quote from the introduction to one of the chemistry outfits, "to satisfy in part this thirst for chemical knowledge and to afford the extreme pleasure derived from the performance of the experiments is the purpose of this chemical outfit. We have aimed to make the subject alive, real and amusing by taking for chemical explanation the things one sees and uses every day of his life." As a statement of aim the above compares favorably with recent thought among leaders in science teaching.

In addition to the materials and manual the boy is flooded with all sorts of propaganda designed to hold his interest and increase the number of sales.

There are the magazines, such as Toy Tips, The Meccano Magazine, and the Chemcraft Chemist, to which he is urged to subscribe. These magazines print his name and address, his correspondence, his picture, they describe new experiments and

answer his questions. Then there are the competitions. As one of the Meccano officials puts it:

> "There are four stages in the boy's reaction to Meccano. In the early days of his play, he is bent on getting the mere *experiences of* manipulating real and workable things. In the second stage he is essentially imitative, duplicating what he sees in the manual. In the third stage, he tends to be original, to invent and originate. And in the fourth stage he emulates the accomplishments of others. Furthermore, there is no fourth stage unless there is something he can compare himself with, something he can strive for."

And so thousands of dollars are offered each year for the best constructions and the best experiments; and tens of thousands of boy competitors flood the mails with their descriptions and photographs.

One of the most effective ways employed by the companies to maintain their hold on the boys is to offer degrees of merit. It is hard for adults to appreciate what the International Society of Meccano Engineers can mean to a boy or to regard with a boy's mind the Gilbert Institute of Engineering or the Chemcraft Chemist Club of America. To receive the degree of "Erector Master Engineer" means quite as much to a boy as the L.L.D. or Ph.D. will mean later on—perhaps more.

Now, let us see what the manufacturers feel to be the value of their toys—not the value of their product over that of someone else, but the intrinsic value of this material. Two types of statements are usually forthcoming, one emblasoned in their advertising circulars to parents and adults, and one to teachers, educators, and the sharply inquiring individual. "Meccano," says Hornby in one of his magazines, is "valuable because a knowledge of mechanical principles gained early in life is an asset that will count strongly in favor of the boy when he rubs against the real problems of later life." And again, "No boy can play with Meccano without being trained in the principles of mechanics and engineering." But talk to Hornby or his representative and ask him what he feels to be the value of his toy and he will tell you that he does not know whether all boys can learn the principles of mechanics, or whether all the principles of mechanics are involved, or how many boys actually learn some of these principles, or even whether they learn any at all. He will talk very assuredly about some things, and will preface most of his statements with "It is my profound belief," or "It is my positive conviction," etc. From the concrete evidence and personal experience which he does possess, he has ventured one positive statement: "The boy is interested, he

is enthusiastic, and he is getting real experiences with things."

Gilbert is even more noncomittal on the value of this type of toy. To a convention of toy buyers and manufacturers he will point, among other things, to the following basic ideals of his product:

(a) To instill into boys the spirit of leadership.
(b) To bring science down to a boys' understanding.

But Gilbert in a private conference will hasten to confess that he does not know what the real values of his toys are. He "feels" that they are worth while. He enjoys helping his boy correspondents. It keeps them out of mischief. They and also he are having lots of fun. And he proposes to go right on perfecting his toys, making them still more popular and in still greater demand.

Without going into further details, it is clear that parents are being flooded with vague, exaggerated, and baseless claims for values that may or may not exist, or values that may or may not be values. It must be very emphatically pointed out that we have not yet been educated to the point where we will look upon the activities of the child when he is out of school with as critical a mind as we regard what he does while within the school walls. Furthermore, it is not quite clear how the various studies and researches which have developed our conception of curricular values can be applied to extra-curricular activities. So that even the parent who is keenly awake to the need of marshalling proper influences around the child at all times has no criteria by which to judge or control the type of materials which are here considered. It is not uncommon to find the chief value of a toy to be the fact that it "helps keep my boy out of mischief," or that it is "the safest and sanest thing I have yet bought," or "it is very inexpensive and absolutely noiseless." These expressions do not always bespeak unintelligence or lack of parental interest in the welfare of the child. It is a far greater indication of the failure to utilize for the development of the child certain forces that are as important as its "schooling."

Play, as a factor in education, is, of course, not new. Some of our leading educators throughout the ages have given it special thought. Plato was the first to give it prominence. And since Froebel wrote his "Occupations" we have had a long list of experimenters and writers on the subject. Spencer found as the chief function of play the fact that it furnished an

outlet for the "surplus energy" of the human organism. Groos and Fiske looked upon play as "nature's method of education," as activity peculiar to "infancy" and of value in preparing for adult life. Later the above theories gave way to G. Stanley Hall's "race recapitulation" theory, and even this theory has been successfully attacked by writings of men like Dewey, who look upon play as being just one phase of the normal life of the child—important in its own right and worthy of being an end in itself. As Merriam puts it in his book on Child Life and Curriculum, "Education through play is a misconception and an abuse of play. Play through education is a more valuable concept."

The tendency then among educational thinkers is to establish values for play activities that are in a different sphere or on a distinctly separate plane from curricular values. This may ultimately be developed in as detailed and thoroughly applicable a set of criteria as we have for curricular studies, but in the absence of these newer standards there can be no more valuable evaluation of the materials and activities we are here discussing than to compare and contrast them with activities of the classroom. Whatever the standards are that we apply to school work, how will the Meccano boy and the Gilbert boy measure when the same standards are applied to them? Obviously an answer to this question will orientate our problem, and is the very first question to settle, because it will determine to a large extent whatever else may follow.

The science activity that most nearly parallels play with science toys, especially for the boy of the age that we are considering, is the course in elementary or general science. A close study of the recent trend toward a first course in science brings to light one large aim from which the values of the study are to be derived. There has been considerable discussion and in many cases even bitter disagreement as to choice of content, its organization and method of instruction, but there has now evolved almost unanimous agreement that General Science or Elementary Science or the First Course in Science should aim to acquaint pupils with their environment. Other aims and especially their relative importance and desirable emphasis are still very much mooted questions, but that environmental science is the starting point for all writers of texts and framers of courses of study, there is now general agreement. The chief worth of classroom science activity is

the increased knowledge, appreciation, and control of the environment. The street environment, the newspapers, the theatre, etc., are all analyzed for the elements of science that they contain and materials and activities of the classroom take their origin in them.)

Next to environmental knowledge and environmental control, there is greatest agreement on the proposition that we should teach science so as to enable our pupils to appreciate the method of science and to use this method and the thinking procedure of science in their everyday lives. Obviously there are several aims involved in the proposition. Some of our leading educators in science teaching, who realize the limitation of a beginner's course in science, are content if this course but serves to inspire boys and girls to further study of science. Eventually the value or values sought are the habituation of the individual to the greater use of scientific thinking and experimenting, and possibly the development of those individuals who can contribute to the advancement of science in the way of discovery and invention.

To these two groups of major aims from which evaluation proceeds, there are usually put forward other aims which, though very important, have not received the same degree of general approval. General or Elementary Science is taught for its civic value, for its vocational value, for its avocational or cultural value, and for the enthusiasm and interest which it arouses in a large proportion of any class: Civic value because of the large number of commercial, city, state, and national functions that are intimately tied up with the practical applications of scientific laws and principles; vocational value, because of the inspiration that frequently comes to a boy or girl to choose some field of science as a life work due to the discovery of an "original" talent. This discovery usually comes through contact with the materials and activities of the science course. Avocational value is claimed because of the larger applications which are made possible by a study of science. The universe, the heavenly bodies, the forces of nature, all offer real aesthetic experiences that are heightened by a keener understanding of them. And, of course, science has been the source of the greatest proportion of life hobbies of the more genuine kind. Finally, the mere enthusiasm evoked by well conducted courses in science is always a desirable characteristic about a pupil because it furnishes a hold on him which can be

utilized in many ways to further the general efficiency of instruction.

Accepting the above analysis of aims and their corresponding values for curricular science—especially that science which is commonly given to a boy during his "toy age"—it is proposed to also adopt the analysis for extra-curricular science. To recapitulate, and in terms of our after-school materials, the criteria which give a science activity value are these:

(a) Does it make for an effective increase in the knowledge of the science of our environment and of its control? That is, does playing with toys help a boy to know better—

what things are
why things happen
how things work
how things are made and
how things are used?

Does it also give one greater skill in—

using things and
making things?

(b) Does it increase his ability to construct? That is, does it make him more adept at manipulating things and does it increase his ability to fashion raw materials into usable things.

(c) Does it make for experimentation and inventiveness? That is, does it inspire the boy to experiment, to try out new things, new ideas, new combinations, and to test these ideas in experience?

(d) Does it have vocational value? First, will it inspire one to further study of science? And, second, will it inspire one to take up a certain vocation.

(e) Does it have civic value?

(f) Does it have avocational value?

(g) Does it involve an attitude or spirit of work that is in accord with

(I) Dewey's "Interest and Effort"
(II) Thorndike's "Law of Set or Attitude"
(III) Kilpatrick's "Purposeful Activity."

Having thus set up criteria for measuring the educational value of play with scientific toys, the first essential was to bring this play under as close observation as was the classwork in science and yet not deaden its spontaneity in any way. This was accomplished by means of a Science Club with a program of activities that brought the boys into the school for some of their "play."

A second essential was a common ground; that is, a common body of content, so that the comparison would be a fair one. This raised a serious problem. To teach the things that boys will play with is to introduce a control on teaching that may work to its disadvantage. To make boys play with the things they are taught (if that were possible) would be to destroy completely the "play." To solve the problem, two procedures were adopted. During the year 1919-1920, the play was

permitted to go on uncontrolled, as was the teaching. At the end of the year a good deal of overlapping was found to exist. Tests based on this overlapping material were used as a means of measurement. During 1920-1921 a series of play units were chosen on the basis of the most popular toy, and the entire course of study for the year's teaching was developed from these play units Thus the teaching was "controlled" as was also the play to a lesser extent, and the tests given were entirely on an identical body of content.

During the two years the comparisons drawn were among four groups of almost equal mental age. Group A[2] in both cases had not only the teaching but also the play.

Group B had only the teaching. Group C had only the play, and Group D had neither. The last group was introduced as a control group.

During 1920-1921 the total amount of time spent on teaching was twenty periods of 30 minutes each and twenty periods of 15 minutes each, allowing 45 minutes during each week up till the end of March. The time allotted to play was a 35 to 45 minute period a week for 20 weeks.

At the end of each year, four types of tests were given to all groups. There was first the traditional type of test that teachers usually employ to find out what knowledge their pupils have carried away (the written test). Second, a test was arranged in which a series of phenomena were enacted before the class, the latter being given two minutes for each phenomenon in which to write their explanation and understanding of what they had seen (the visual test). A third test was one in which each pupil was asked to do certain tasks with actual materials (the practical test). And finally as a measure of constructive ability the Stenquist Box Test was used both at the beginning of each year and at the end.

Here are a few of the significant results (averages) of these tests:

Group	Average I. Q.	Stenquist No. 1 (before)	Stenquist No. 2. (after)	Visual	Practical	Written
A	110.5	55	64.4	73.5	73.6	65.3
B	113.0	52	50.5	57.2	40.2	50.7
C	107.6	36.4	47	42	53.6	37.1
D	110.8	37.6	36.8	27.4	19.8	8.2

Though Group A shows superiority throughout; and group

[2]Groups C and D were drawn from the fifth grade, whereas Groups A and B were drawn from the sixth grade, thus the former were, on the average, one year mental age younger than the latter.

C (after a year's mental age difference is allowed for) shows superiority over Group B even in the written test, it is in our second general aim, environmental control, that the value of our play materials become marked.

In the type of ability represented by the practical test, Groups A and C are far superior to the rest. In a sense, environmental control is more important than mere knowledge or information, for it involves the functioning of this knowledge in life situations. How often do we remark upon the vast chasm that exists between being able to explain to the physics teacher how an electric bell works and the ability to repair the house doorbell. The utter helplessness of the average individual who is confronted with a balky vacuum cleaner or an electric socket that won't work or a blown fuse or a leaky water faucet is regarded by many as a sad phase of modern city life. We rely too much upon the mechanical expert who weaves around himself the autocratic halo of the physician and who regards poor ordinary mortals as incapable of understanding what ails them or rather their house appliances. Just as in medicine, so in things mechanical and electrical we ought to encourage and train individuals to care for their physical belongings intelligently. The ounce of prevention maxim holds just as truly in this field as in medicine. If the course in hygiene aims to make the doctor a less necessary commodity, so after-school activities in science can serve to make less necessary the plumber and the electrician. The most interesting result of the practical test is the small amount of carry-over or transfer which there was between the class-work and the ability to do the actual tasks with materials. It is clear from the table that the curricular work did not help Group A in getting their high score in this test, for Group C, without the curricular work, did better than the much older boys of Group B. In this connection, we might mention again the common criticism of modern society as expressed in the writings of Dr. Eliot and others, in which the loss from the home of opportunity for sense-experiences is very much regretted. The writer wishes to point out that this opportunity still exists, but in a different form. In a sense, there are more of these experiences possible; they are more interesting, and involve a greater amount of intelligence and knowledge. The stimulation to such experiences is furnished to a great extent by these after-school activities in Science.

To summarize briefly the conclusions and items of interest uncovered by this study, we may list the following:

1. In general the very expensive toys are not more educational or more fun-producing than are the less expensive ones.
2. The number of toys a boy possesses increases until he is eleven or twelve years of age. The number stays constant until he is fourteen, when it begins rapidly to decrease.
3. At fourteen years of age there is a marked change in the type of interest that a boy has in toys. Though after-school science activities do not diminish appreciably, there are no toys sold which meet his needs completely.
4. The toy outfit is far more popular than the specific toy. (An outfit is distinguished from a specific toy chiefly by a greater wealth of experimental possibilities and original adaptations.)
5. Of the five hours of each day that the average Horace Mann boy has free to do with as he chooses, roughly three hours are devoted to science toy activities of various kinds; the other two to athletic games.
6. Activities with science toys come at irregular intervals and for long and protracted periods. They are usually accompanied by great enthusiasm and often by dreams at night and by day.
7. A large proportion of boys who own science outfits carry on correspondence with the manufacturers of their toys. As many as 2500 letters a day have been received by one firm during the months of November, December and January.
8. An analysis of several hundred letters shows the chief interest (37% of the boys) in these toys to be a desire to "do things, make things work, make experiments, and invent." The interest that ranks next (23%) is in the winning of a prize or diploma. The interest that ranks third (20%) is in being a great engineer or inventor.
9. Most of the letters are written because the boys wish help. The chief source of difficulty (54%) of the letters is due to lack of knowledge. The difficulty next in importance (25%) is due to highly impractical schemes. Lack of ability or technique accounts for 18% of the difficulties.
10. As shown by the letters, two-thirds of the boys succeed in overcoming their difficulties. One-third fail. Half of those that succeed do so because of continual experimenting—trial and error. The other half succeeds through help or hint from parent, teacher, or friend.
11. The companies do practically nothing for the one-third that fail.
12. The chief characteristic about a boy who succeeds in overcoming a difficulty is that he almost always finds a new problem arising out of the old one.
13. For every boy who follows the order of the experiments as found in the manual, there are seven who skip around throughout the manual, performing experiments at random. The manuals do not function as they are intended to by the companies.
14. The "random" boys are superior to the others in inventiveness and originality (as measured by their standing in the Science Club.)
15. Many of these "random" boys develop a steadier interest in the manuals later on; that is, they pay more and more attention to larger ideas and concepts as developed by the manual. Guidance and control at these critical stages is, of course, important and is furnished to some extent by the club.
16. The mechanical toy of greatest appeal is the electrically operated derrick that moves and lifts.
17. There is a growing tendency among manufacturers to abandon the type of toy that appeals merely to the two elementary sensations of motion and color, and to produce a toy that is "meaningful."

This tendency is the correlate of a great demand for this sort of toy, that is world-wide.

Applying curricular standards to this activity we find, that

18. Extra-curricular activities in science make for better control of the physical and chemical elements in our environment.
19. Extra-curricular activities in science make for almost as good a knowledge and appreciation of environmental phenomena as do curricular activities.
20. Extra-curricular activities in science make for better constructive ability; that is, ability to fashion raw material into usable things.
21. Extra-curricular activities in science encourage and stimulate activities that give the boy first-hand experiences with natural phenomena. Their activities agree closely with the useful activities of great scientists and they contain elements in common with the laboratory procedure of great scientists.
22. Extra-curricular activities in science represent a type of purposeful activity which encourages originality and inventiveness and habituates boys to the experimental procedure.
23. Boys who participate in both curricular and extra-curricular activities excel all others in the abilities mentioned above.
24. Clubs and societies for boys of the ages 11, 12, 13 and 14 take advantage of an instinct that is very dominant during those ages. The propaganda of the manufacturers, the different toy institutes, etc., utilize this instinct essentially for their own purposes.
25. Experiences of large organizations of this type in the past show the need of three things: Workable materials, a definite program, and intelligent leadership.
26. The Science Club is an organization which may serve as a medium through which after-school activities in science may be stimulated, guided, controlled, and developed.
27. The Science Club should have a science play shop where are offered the proper physical facilities for the efficient carrying-on of after-school activities *in school.*

Do not fail to attend

The Annual Meeting of the Central Association of Science and Mathematics Teachers

at the Hyde Park High School, Chicago, December 1 and 2. A splendid program has been provided. Many prominent men will be there. It is without doubt the best program which has ever been arranged.

Come and renew old acquaintances.

SUGGESTIONS AS TO CHANGES IN ENTRANCE REQUIREMENTS IN SCIENCE.[1]

By W. J. A. Bliss,
Collegiate Professor of Physics,
Johns Hopkins University, Baltimore, Md.

Introductory:

I was reluctant to accept the invitation to address you on this subject, owing to lack of technical information as to present requirements, but consented to do so because of its bearing on the college course in General Physics, which I have been studying in connection with a report in preparation for the American Physical Society on Physics in Medical Education. This course presents a very difficult problem which is rendered more so by present defects in the preparation of the student entering college. I therefore welcome the opportunity to bring these difficulties to the notice of those who are formulating entrance requirements. Inquiry shows that present entrance requirements in science affect the first course in chemistry almost as disadvantageously as they do that in physics, and the same appears to be true of other sciences. The presentation from the standpoint of general physics and general chemistry will thus apply to all students intending to take a course in science at college, and since at least one such course is generally required for graduation, it is suitable for a general entrance requirement. It is, however, absolutely limited to the ten per cent of high school students who do go to college, and would not fit the needs of the ninety per cent who do not. The problem of rounding up a pupil's education in the four high school years to the best possible finish is totally distinct from that of preparing him for from four to eight years more of study and no specifications can be offered for a science course to serve two such diverse purposes. It would be as easy to specify a standard foundation equally suitable for a two-story dwelling and a skyscraper.

Difficulties in the First College Course Arising from Defective Preparation for College.

Talk with the instructors of the first college courses in mathematics, chemistry and physics and you will find very similar opinions with regard to the preparation and ability of their students in many respects, but each wants more school study in the other two subjects, but so far as possible a virgin field in his own! Each will tell you that the school courses introduce in-

[1]Address delivered at the Opening of the Science Section, at the Thirty-Fifth Annual Convention of the Association of Colleges and Preparatory Schools in the middle States and Maryland, Swarthmore College, November 26, 1921.

equalities among their students, which give rise to insurmountable practical difficulties in teaching. This is largely because the school course is commonly not treated as a problem totally distinct from the college course. The school tries to give a less thorough imitation of the college course, simply an abridgment. School text-books in physics and chemistry are mainly abridgments of college texts, frequently by the same author. In chemistry, for instance, there is an attempt to cover all of inorganic chemistry and even to close with qualitative analysis, which owing to the student's limited repertoire of reactions can only be of the cook-book type. The school text naturally omits the harder and duller parts and emphasizes those where interesting facts can be presented with minimum effort.

The ruinous effect on the college course is evident. Nothing can be omitted because the school treatment simply lacks thoroughness all through. The student recognizes some little fact and thinks "I know all about this." Instead of greeting the old friend with loving interest he takes a little nap, during which the teacher explains the great principle which was considered too abstract for the school text. The college teacher has to emphasize all the dullest and driest parts of his subject, and the student is bored and disappointed. The situation is even worse when you have gross inequalities in knowledge among the students so distributed that no systematic course can be fitted to them. Yet the separation of the first course into two courses, one for students who have had physics, the other for those who have not, as at most colleges, is not very satisfactory. In the first place it presents the illogical aspect of two parallel courses, counting equally as prerequisites for other courses, but of apparently different grades, since one requires a previous study of the subject which the other does not. At Johns Hopkins we have really three distinct categories, those who have had no physics in school, those with high school courses of very varying value, and others still with a fair high school course plus a year or two of engineering applications. Shall we give three parallel courses?

Technical Terminology.

Physics presents another difficulty which is seriously affected by the school course. In no science are the technical terms so largely drawn from common speech. It abounds with words used in highly technical senses narrowly restricted to very rigidly defined meanings, so that they are capable of exact mathematical

expression, and which are in common use in wholly vague and often entirely different meanings. "Weight," "force," "power," "energy," "momentum," "heat," are only a few of the most obvious. Professor Franklin has said that the grocer and coal man call "weight" what the physicist and chemist call "mass," but it is even worse than that. If the coal man overloads his cart and the axle breaks, he will attribute it to the "weight" of the coal, whether it breaks standing still or owing to a jolt going over the car track. In the first case he uses the word in the scientific sense; in the other he does not. Physics is full of such man-traps, of which even college teachers are imperfectly aware, and which greatly increase the difficulty of the subject as a school study. The teacher must drive out the old conception and insist on the new and correct use of the term, and the student who comes to college with a year of physics under a teacher who has not done this is simply confirmed in bad habits. I heard a high school science teacher say that he did not "stress" the difference between mass and weight, because it is important only in distant and out-of-the-way places! When such fundamental misconceptions are transferred to definite mathematical formulae the trouble is vastly increased.

Another difficulty arising from school physics is that of incorrect definitions given the pupil with the idea that they are easier than the correct ones. The glaring example of this is the definition of e. m. f. as a pressure which forces through a wire what is called technically an electric current, but which the pupil much more consistently refers to as the "juice." The student is thus started with a wholly incorrect conception of potential difference. Other mistakes from which the college teacher reaps the whirlwind are such phrases as "heat in a body," "converting work into heat." It would be as lucid to speak of converting one's legs into a trolley car when one walks instead of riding!

Mathematical and Other Teaching Difficulties in General Physics.

Among the reasons that make the problem of general physics so difficult that a reconsideration of entrance requirements seems essential are those resulting from the fact that, more than any course, it is taken as a prerequisite to other studies and by students who take no second course in the subject. At Johns Hopkins 95 per cent of the class are in that category. This means that it must come early in the curriculum and that it

must be final and give the needed vocational working knowledge. It is utterly impossible to cover the entire range of even the most important applications, even in one field like medicine. What we must do is to enable the student to read physics and give him the habit of reading it for himself. We must therefore in large measure teach the general principles and leave the applications to the student, giving him simply a list of references. Moreover we must cast the principles in the mathematical form in which they will be found in books of reference and technical articles generally. That is, we must use trigonometry freely, and a modest amount of analytics. In as much as nature has at least three dimensions, we cannot stay entirely in flatland, and we have to assume that the student has a concrete idea of such things as spheres and cones and pyramids: of ellipses, parabolas and hyperbolas and of their foci and axes. These terms are simply the common equipment of scientific and professional men everywhere and we have to assume it. Not only must the student know these things but he must have attained reasonable efficiency in using them, as well as skill in the accepted school mathematics. He must also be in the habit of using the ordinary labor-saving devices, such as logarithms, and all of these things must, so to speak, be on the tips of his fingers. He must have reached the point where mathematics is to him a help and not a hindrance. The English schools I think accomplish this while ours do not. He must furthermore be in the habit of using mathematics as an aid to thought and not a substitute for it. He must visualize the concrete things that he is discussing and see in the equations only a convenient system of shorthand. He cannot possibly do this if he has been taught to cram "formulas," and solve problems by merely substituting numbers for the letters.

Finally general physics like any college course, and perhaps more than any, requires the habit of personal responsibility of the student for his own progress. We must not only rely on him to study a great deal that is set forth with reasonable clearness in the text-book, so that we may economize our time for the things that are really difficult, but he must test his knowledge by working more problems than we have time to correct. He must in a measure be his own taskmaster and look on his teacher as a guide and helper. Instead of that he expects all his work to be covered in class, and looks on the teacher as a taskmaster to be eluded when possible.

To mention only one defect which strikes directly at teaching efficiency, our investigation of the general course in physics showed that while teachers generally consider the working of many numerical problems essential, all agreed that home work cannot be accepted. Most of the college teachers recommend a provision of "Problem Periods," usually replacing about half of the laboratory time, and devoted to the childish process of working problems under the teacher's eye, because that is the only way he can get them done at all! Please don't think we blame the schools for a lack of a sense of honor, but we do blame them for the fact that a young man or woman of eighteen or nineteen still expects the professor not only to teach him but to "learn him." Even McFadden must have found he had to practice "on his own" before he was "learned" to waltz.

To summarize, the difficulties which we are trying to meet by a change in the entrance requirements are of three kinds:

1. Definite lack of certain mathematical knowledge, which is essential to the study of science in college.

2. School courses, which try to forestall the college courses in science, and which should be replaced by others of a type definitely preparatory to them.

3. Incorrect habits of study, which are largely the fault of the college entrance examinations themselves. So long as the colleges fix the passage of certain examinations, whether set by themselves, or by an Entrance Board, or a Board of Regents, or even by the schools themselves, just so long will school teachers endeavor to cram boys with formulae and tabloid facts for use in the examinations. To this extent the trouble is not with the entrance requirements, but with the mode of determining whether they have been complied with, not with the specifications but the method of testing the goods on delivery. To overcome it we must either devise an uncramable examination or accept the recommendation of the school teacher, based not on examination but on day by day knowledge of his pupils. In the latter method the college must of course support the conscientious and efficient teacher and check the easy-going one by some arrangement of quota, which may be varied from time to time in accordance with the success of that school's product in the work of the college.

Part II. Suggested Requirements.

Summary: It is evident that these conditions are to be met rather by a change in content of the courses and in the method of

instruction, than a change in subjects, and that this will be hard to accomplish under the examination system. With this warning the following distribution of time is suggested, based on a total of 4 units of science. I must, however, remind you that the courses are proposed with the intention of preparing the student for the college course in science specifically, and not as general information or cultural courses. I should divide the four units as follows:

1. Mathematics, *1 unit* if needed.
2. General science, *1 unit*.
3. A good strong course applying the principles studied in the course in general science to some one science, such as physical geography or biology, *1 unit*.
4. *A unit* divided between chemistry and physics and extending the knowledge begun in general science.

If, owing to the introduction of courses in "general mathematics" the additional preparation specified below can be given without requiring an additional unit of mathematics, I would suggest one year each of *physics* and of *chemistry*.

I will now take these up one at a time.

Mathematics: The time corresponding to the additional unit in mathematics is to be utilized in extending the working knowledge of the student in mathematics applied to science. It is not intended as an additional systematic course in any one or more subjects. I must leave to the mathematics teacher the question whether this time can best be utilized by distributing it or by collecting it in a single course in the fourth year high school, so planned as to form a review of formal mathematics, unifying its teaching, adding the specific information absolutely essential to science teaching and giving practice in rapid and facile application. It should in addition to algebra A and B and plane geometry cover: Logarithms; sine, cosine, tangent and cotangent, the signs of these functions in all quadrants, the eight or ten most useful relations between them; and abundant practice in applying all of these not only to triangles, but to such problems as lengths and directions and angles between lines, both in two and in three dimensions, direction cosines, vectors, etc. In analytics it should cover the idea of rectangular co-ordinates in two and in three dimensions; distances; lengths of lines; angles between lines; equation of the line, the circle, the ellipse, the parabola, foci, eccentricity, axes, curves as loci, intersections as solutions of simultaneous equations. The course should also include the description of the chief regular solids, such as the

circular cone and sphere, the surface and volume of a sphere and the analytical measure of plane and solid angles.

The availability of this knowledge for any freshman course in science is becoming absolutely essential, and this is the only excuse for advocating a course that cannot possibly be made systematic or entirely rigid. Perhaps the proposed courses in general mathematics will accomplish this object without the credit of the additional unit. I am told by our mathematics department that the question of general mathematics is largely one of detail and that one at least of the more recent books meets many of the objections of the more rigid and formal mathematicians.

An essential requisite is that this new unit shall be reflected in the college entrance examinations, so long as these are retained. This should be done by requiring problems to be worked involving them and not by asking for proofs of formulae, etc. Looking over the Entrance Board Comprehensive Examinations for several years, I am struck with the entirely academic character of the mathematical papers, and blame the poor showing of students in science largely on the type of teaching which they must engender. To be of real use such a course as I have suggested should limit the cramming of formulae to the most essential ones and otherwise should eschew the whole formula idea in teaching.

General Science: The course should be of a type similar to Hessler's *General Science*, which happens to be known to me. Those based on the project idea, "Science in the Home," and all the rest of it, confuse the idea of teaching with that of learning for one's self. Boys and girls ought to be taught to apply all their studies, including science, to their everyday life; this should, in fact, be their laboratory. Books of the project type could well be used as reference books for home study in connection with a more systematic and rigid course taught at school. Too much stress cannot be laid on encouraging the student to observe what goes on around him and to seek the explanation, and the course in general science should foster this in every way, perhaps by asking for periodic reports of something that the student has looked up for himself. It should develop the student's perceptions quantitatively in terms of common units. He should be encouraged to estimate dimensions, weights of bodies, to grade temperatures roughly, and to note the salient characteristics of common materials; that brass and steel are springy, copper much less so, and lead hardly at all, and all such facts. In other words, his observations should be concrete.

Students now enter Johns Hopkins who do not know steel from copper or oak from cherry.

Where mathematics is used in general science it should be of the simplest, and the formula should be avoided like poison.

3. *Second Course in Science:* The second course should afford an exercise in applying the first course along some definite single line, and physical geography is suggested not because of its own importance so much, as because it appears to apply physics, chemistry, biology and geology most simply and aptly. Moreover one might use such a book as Huxley's *Physiography*, or Geikie's *Physical Geography*, which are not cut up into pills for ready cramming, but have an additional value as literature and as the work of two masters of science.

4. *Physics and Chemistry Course:* The schools should decide whether the two subjects should be taught parallel, or one should follow the other. The essential idea is to give a more precise and extended knowledge of each subject than can be given in general science, but to avoid a course in any way similar to the college one, or which might possibly be looked upon as an abridgment of it or an attempt to serve the same purpose. Each subject should be taught so as to afford that general basis for the other subject which is needed so much in college. The college course in General Chemistry must deal with fluid pressure, manometers, barometers, thermometors, melting and boiling points, temperature scales, the gas law, ions, electrochemical equivalents, refractivities, and so on. General Physics must discuss molecules, atoms, combining weights, chemical equivalents, formulae of simple chemical compounds, energy relations in solution and crystallization and in chemical reactions. The school course ought to furnish this background in a pretty definite form without attempting the rigid systematization and the completeness of the college course on the one hand, or becoming merely a heterogeneous mass of miscellaneous information on the other. Amongst other things it should give the student the same general picture of the structure of matter, which is in the college teacher's mind, and which is so familiar to him that he may not realize its absence from that of the student. The entering student should picture matter to himself in terms of the general concepts of the kinetic theory, as made up of atoms, molecules, ions, electrons, in motion. He should use these terms with reasonable correctness and should have a general idea how the familiar properties of natural bodies are explained by a hypo-

thesis, which is a matter of course to the scientist but quite foreign to the minds of the uneducated.

Chemistry: Being unfortunately not at home in chemistry, mine being self taught, the only suggestion I am prepared to make is on the authority of our department of chemistry. They think that the course should be limited to the non-metals, and that if this were done there might be a substantial saving of time in the college course, which would cover this part of the subject by a comparatively brief review. Qualitative analysis they are much opposed to, as the number of reactions really at the command of the student is too small, even after the most elaborate of the present school courses. In fact, qualitative analysis at Johns Hopkins has now been changed to the end of the second year of chemistry, following after quantitative analysis. It affords a useful review of a much more complete course, and, if taught by other than cook-book methods, it is really harder than quantitative analysis.

Physics: In the field of physics I am naturally more at home. Since physics is essentially quantitative, it would be hard to give a useful course, which does not involve measuring and computing. The student should also be taught to demand proof of a scientific statement and, the laws of physics being mostly quantitative, a quantitative proof is necessary. On the other hand even our college courses carry rationalization much too far. To the physicist the great attraction of the science is the possibility of deducing its laws from a very small number of great concepts, but more judgment is necessary than is commonly shown in carrying this process into elementary teaching. The ultimate basis being experiment, it seems to be merely a question of pedagogics whether in a given course we assume two fundamental experimental laws and deduce twenty others from them, or assume ten and deduce the other ten. The vital and illuminating associations between one phenomenon and another, for instance, between Archimedes' Principle or Torricelli's Law of Efflux and the conservation of energy, should be guarded by all means and many deductions of one phenomenon from another should be made to teach such associations. But the simple proofs are the valuable ones in elementary instruction, and we should always beware of the proof which has no point except the attempt to rationalize, particularly when the attempt is incomplete. For example, the deduction of the Principle of Moments in Jean's Theoretical Mechanics from the dynamics of a particle

and the degrees of freedom of a rigid body is a splendid exercise in reasoning for an advanced student. A similar discussion is wholly out of place in an elementary book, even for college students, and the deduction is usually so incomplete that it not only does not inform but fails to convince. Why not state both the principles of equilibrium of a rigid body baldly as experimental laws, and begin right there?

In a school course in physics, one should keep very close to an experimental basis with as little theory and mathematical deduction as possible. One should emphasize the great quantitative laws, however, but be very careful not to let them become formulae. In mechanics, one should emphasize equilibrium of forces, work and energy. One should introduce conservation of energy as early as possible and use it as the connecting thread for the whole course. Properties of matter are easily treated experimentally—particularly hydrostatics and gases—and so is heat. One should deal very lightly with electrostatics and magnetism and dwell on the fundamentals of direct currents. Periodic motion and waves should be taken up descriptively, defining the technical properties frequency, wave-length, etc., and calling attention to energy changes in vibrations and the propagation of energy by waves. Dwell on the physical explanations of lenses and mirrors and generally emphasize physical rather than geometrical optics. Give a great many simple numerical problems, but avoid formulae, except possibly a few expressions of very frequent occurrence, and these only allowed after many similar examples without formal statement of the equation. One should be very particular about units, and that the student understands the arbitrary nature of the process by which a number is made to represent a concrete quantity. He must also be accustomed at the start to the fact that an equation representing a law will vary with the units, so that the law is the thing to learn, not the equation.

Avoid formal definitions, but be very careful in the use of terms to follow the precise usage of the science. For instance, one should never use "*power*" except for rate of work. Instill the correct significance of a term and not an analogy. For example: An electromotive force is often described as a "pressure," forcing the current through the wire. The energy relations of the circuit present no greater difficulty and lead to a correct idea of e. m. f. as the amount of energy furnished the circuit by the source of energy per unit charge passing through.

As in the case of mathematics, the college entrance examination would have to be shaped to encourage such a course. The papers now given seem vastly better than those in mathematics, but there should be more descriptive questions and fewer for which formulae can be crammed. For example, one might ask such questions as: "What three fundamental phenomena combine to produce the increasing resistance experienced in pumping up a tire? State the laws of these phenomena and the names by which these laws are known." Or "Explain fully why a distant object may be seen clearly through a convex lens if far enough from the lens or near enough to it, but becomes blurred at an intermediate distance."

Laboratory Work: The laboratory work should be largely qualitative and consist of many short and simple experiments rather than elaborate ones. The apparatus should generally be simple and all parts readily visible. But whenever measurements are made, reasonable care and precision must be insisted upon, to train the faculties and to avoid the formation of careless habits. A neat and systematic original entry, curves well plotted to intelligently selected scales, and computations neatly entered, should be insisted upon. Mental arithmetic, logarithms and the slide-rule should be the only methods of computation tolerated, and the observance of significant figures should be taught. The student should be taught to criticize his own work and that the importance of a given mistake depends on its proportion to the quantity sought.

The school should, however, not shirk its share of the duller drill work of actual training in simple, scientific technique. Not only should the student be taught such things as simple glass blowing, electrical connections, etc., which have some fun in them, but should be drilled in the precise and correct use of the commonest scientific instruments, which require no theoretical knowledge whatever. For example: Measuring time intervals to a fraction of a second with an ordinary watch; correct and incorrect use of a rule, and eye estimates of fractions of a division; testing a thermometer, reading it to a tenth of a degree, and a reasonably sound technique in its use; reading a barometer and correcting it for temperature; use of calipers, including verniers; how to focus a microscope or telescope; weighing rapidly and up to the accuracy of the balance provided. He should from the start be taught the falibility of instruments and form the habit of

noting zero readings and making simple scale corrections. In other words: *"Start him right!"*

Summary: If four science units are accepted for entrance they should be modified so as to include:

1. A course in general science intended to familiarize the pupil with the most obvious natural phenomena, without reference to the science under which they are commonly classified, and also with the characteristic properties of common objects and materials. It should not be of the "project" type, but projects may be assigned for outside reading or as subjects for compositions.

2. A more systematic course in some one science applying the knowledge gained in general science.

3. A course, which might be styled "physical science" combining both physics and chemistry and intended simply to give that fundamental knowledge of each which is essential to the intelligent study of the other. That is, it should be preparatory to the college courses in these subjects in the same way that the general science introductory course is preparatory to course (2). It differs from the first course by being more advanced and thorough, but must on no account forestall or be an abridgment of the college courses. The laboratory work should be illustrative and simple, and such as to demand little theoretical knowledge, but it should include training in simple laboratory technique, and care should be taken that good habits are formed.

4. A course in mathematics intended specifically to prepare the students for the study of science in college.

It is intended that the last two courses shall be taken simultaneously in the last year before entrance. A high school student who does not expect to go to college might advantageously take the first two courses, and possibly that in mathematics, but a more practical type of course should by all means be substituted for that in physical science as outlined.

SODIUM WIDELY DISTRIBUTED

The element sodium is very widely distributed in the earth. It forms about 2.36 per cent of known terrestrial matter, according to the United States Geological Survey, and is the most abundant of the alkali metals. Sodium appears to occur in nature only in combination with other elements, if its alleged occurrence as the free element in blue rock salt is neglected. It is an important constituent of the feldspars and several otner insoluble minerals from which sodium salts are not extracted commercially but wnich are nevertheless regarded as the ultimate source of the salts that are soluble in water.

TESTS IN BIOLOGY AND GENERAL SCIENCE.

By A. B. Wells,
Concord Normal, Athens, W. Va.

The ordinary examination is being replaced more and more by tests patterned after the general intelligence tests.

The advantages of the new style of test are the covering of more subject matter in a given time, the greater speed and accuracy in grading the papers and the greater diagnostic value of the papers. The main objection to the new style of test is that the wording is fixed, giving the pupil no chance for the original expression. It is also claimed that the new test is a memory test and not a thought test, but my experience leads me to believe that such is not the case. Lack of thought was responsible for many errors in the answers which were correct.

I am not familiar enough with the many texts used in biology and general science to formulate a general test for a year's work in either of these subjects but I have made out six-weeks period tests and semester tests based on the tests I was using, with results very satisfactory to me. The text book in biology was *A Civic Biology* by George W. Hunter and the text in general science was Caldwell and Eikenberry's *General Science.*

In the semester tests I avoided true and false statements altogether as I believe their diagnostic value is very poor. A student who really knows 50% of his subject is likely to get a score of zero by subtracting the wrongs from the rights, in scoring.

The mutilated sentences were used entirely in the semester tests, as I got the best diagnostic results from them in six-weeks period tests in which I used true-false statements, selection of words in completing sentences, and mutilated sentences.

In choosing sentences the aim was to use those which expressed the most important principles and facts.

The sentences were mimeographed at an expense of about five cents a pupil for 100 pupils.

Copies of the tests compiled and used are appended.

The semester test was given only to students averaging less than 85% or BB for the semester as all students averaging 85% or more were exempted.

Biology Test No. I.

Fill in the blank spaces in the following sentences with the proper words.

1. The process by which two gases or fluids separated by a .....

tend to pass through the ..... and mingle with each other is called .....

2. Root hairs give off a small amount of ..... which turns a pink alkaline phenolphthalein solution .....
3. The elements found in plant protoplasm are 1. ..... 2. .... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8. ..... 9. ..... and 10. .....
4. Plants which combine with the ability to scatter many ..... seeds over a wide territory the additional characteristics of rapid growth, resistance to the dangers of extreme cold and heat attacks of enemies, inedibility and peculiar ..... to cross pollination or ..... pollination are usually spoken of as .....
5. The compound leaf of the poison ivy has ..... leaflets but the compound leaf of the Virginia Creeper has ..... leaflets.
6. Linen is made from .....
7. A substitute for olive oil is made from ..... seed.
8. Black and red pepper, mustard, allspice, nutmeg and vanilla are made from ..... or ..... of tropical plants.
9. Tea is made from the ..... of the tea plant.
10. Cocoa is made from seeds of the ..... plant.
11. Coffee is made from the ..... of the coffee plant.
12. ....., ..., and ..... are staple foods from trees in the Mediterranean countries.
13. ....., ..., and ..... are fruits of the citrus family grown in Florida and California.
14. ..... and ..... are diseases prevented by eating vegetables and fruits.
15. The cereal grains are: 1. ....., 2. ....., 3. ....., 4. ....., 5. ....., 6. .....
16. 100 bushels of .... has the fuel value of a ton of coal.
17. ....., ..., ..., ..., ..., and .... are roots which store food.
18. Sugar is made from ...., ..., and ....
19. A cabbage head is a big ..... which has been cultivated by man.
20. ..... is the greatest destroyer of the forest.
21. Growth from stumps is called ..... growth.
22. Thinning out the largest trees at maturity is the most ..... method of renewing the forest.
23. Cutting strips through the forest can be used only with trees having ..... seeds.
24. Forests may be renewed by ..... planting.
25. ..... and ..... are the main sources of fires in forests.
26. The making of foods into living matter is called .....
27. The span of life from the time the plant or animal begins to grow until it dies is called the ....
28. The .... catches insects in a sensitive leaf which folds up and holds the insect fast until ..... poured out by the leaf slowly digest it.
29. The ..... has sensitive sticky glandular hairs on one side of the leaves which catch and ..... insects.
30. The stem of an exogenous tree is composed of ....., ..., and .....
31. The raw materials from which starch and sugar are made are ..... and ....
32. ..... furnished the energy for making starch.
33. The test for starch is ..... which turns it .....
34. ..... act as the machinery in making starch.
35. The green coloring matter in plants is called what?
36. Oxygen is excreted by the process of .....
37. ..... is necessary to form proplasm.

Biology Test No. II.

Underscore the words after the dashes that correctly complete the sentences.

1. Water is held best by—gravel, sand, barren soil, rich loam, leaf mold.
2. Nitrogen is taken from the air and made into nitrates by—yeasts, molds, bacteria, one-celled animals.
3. The cotton boll weevil is a—moth, bug, beetle, fungus.
4. The most important grain crop in the United States is—oats, corn, wheat, rye, rice.
5. Chestnut blight is a—fungus, insect, bacterial disease.
6. The wheat rust is a—moth, fly, beetle, bug, fungus, bacterial disease.

Some of the following sentences are true, others are false. Mark the true ones T. and the false ones F.

1. The root hair is a living plant cell.
2. In osmosis the greater flow is always away from the denser medium.
3. The cell sap in a root hair is less dense than soil water.
4. Water is held in the soil by osmosis.
5. Sodium and chloride are found in animal proplasm.
6. Sodium and chlorine are always found in plant proplasm.
7. No green plants can get their nitrogen directly from the air without the help of bacteria.
8. The Jimson weed is poisonous.
9. Three of the plants which yield fiber also produce oil.
10. Manila hemp is made from the woody fiber of a plant of the nettle family.
11. Nuts contain very little protein.
12. Many fruits belong to the rose family.
13. Cherries, plums, apricots, peaches and nectarines belong to the same genus.
14. Beans and peas contain very little protein.
15. Machine oil and soap are made from corn.
16. An onion is a root.

First Semester Biology Test.

Fill in the blanks in the following sentences with the correct words.

1. ..... is the study of living beings both plant and animal.
2. Human ..... is the study of the parts, uses, and repair of the human body.
3. Plants and animals need the same conditions in their surroundings in order to live, that is ....., ..., ..., a favorble temperature and usually light.
4. The life ..... of both plants and animals are essentially the same.
5. The study of biology ought to make us better men and women by teaching us that ..... exists in the world of nature as well as among civilized men.
6. The 12 elements always found in animal tissues are sodium, chlorine, carbon, hydrogen, oxygen, ..., ..., ..., ..., ..., ..., and .....
7. The Hymenoptera have ..... metamorphosis.
8. The Hemiptera have mouth parts formed for .....
9. The Orthoptera have ..... metamorphosis.
10. The four stages in life of an insect with complete metamorphosis are egg, ..., pupa and adult.
11. The essential organs of a flower are the ..... and pistil.
12. The floral envelope is composed of the ..... and corolla.
13. Pollination is the transfer of pollen from an anther to the ..... of a flower.
14. Each part of a living plant or animal which has a separate work to do is called an .....
15. A ..... is a tiny mass of living matter, containing a .....

either living alone or forming a ..... of the building material of a living thing.

16. Proplasm has the power to respond to .....
17. Proplasm can form new living matter out of .....
18. After fertilization the ovule grows into a .....
19. The test for starch is ..... which turns it .....
20. The test for protein is nitric acid which turns it ..... followed by ..... which turns it orange.
21. The two commonest carbohydrates are starch and .....
22. The parts of a bean seed are the tests, cotyledons, ... and .....
23. Gravity and ..... influence the direction in which roots grow.
24. The process by which two ..... or ..... separated by a membrane tend to pass through the membrane and mingle with each other is called osmosis.
25. In osmosis the greater flow is toward the ..... medium.
26. Dead plant and animal matter in the soil is called .....
27. A pink phenolphthalein solution is turned colorless by ..... given off by living roots.
28. Nitrogen fixing bacteria occur in tubercles on the roots of ..... plants.
29. In the process of photosynthesis, ... and .... are the raw materials, the ..... are the machinery, the ..... furnishes the energy, ... is the finished product, and ..... is the waste or by-product.
30. Protein material is a food which is necessary to form .....
31. The three parts of a dicotyledonous stem are .... and .....
32. In the exogenous stem growth takes place from an actively dividing layer of cells called the ..... layer.
33. Starch is changed to .... in sprouting grain by an ..... called .....
34. Growth from the stump is called ..... growth.
35. Cutting strips in a forest renews the forest only with trees which have ..... seeds.
36. Forests prevent ..... of the soil and .....
37. One source of sugar is from ..... trees.
38. ..... is the greatest destroyer of forests.
39. A ..... in a board is made by a limb grown over.
40. Cabbage, onions, and spinach are ..... used as food.
41. Kohl-rabi, sugar cane and potatoes are ..... used as food.
42. Beets, carrots and turnips are ..... used as food.
43. Corn, wheat, rye, barley, oats and rice are called ..... from ..... Roman Goddess of Agriculture.
44. ..... is the most important vegetable fiber grown in America.
45. Plants which grow rapidly, scatter many seeds, withstand attacks of enemies, drought, heat and cold, and are useless to man are called .....
46. Fungi which feed on dead organic matter are called .....
47. A plant or animal which lives at the expense of another living plant or animal is called a .....
48. The three kinds of plants without chlorophyll which we have studied are ....., ..., and .....
49. Typhoid fever and tuberculosis are caused by .....
50. Ringworm is due to the growth of ..... in the skin.
51. The process of living together for mutual advantage is called ....
52. Plants with chlorophyll build up complex organic substances from ....., ..., ... and simple salts by means of energy from the .....
53. The two most important links in the nitrogen cycle are the ..... bacteria and the ..... bacteria.

54. Pleurococcus is a one-celled .....
55. Vorticella is a one-celled .....
56. Paramoecium moves by means of .....
57. Amoeba moves by means of .....
58. Food enters Paramoecium through the .....
59. Amoeba gets its food by ..... it.
60. Physiological ..... of labor means that each part of a living being does a different kind of work.
61. The four sub-kingdoms of the plant kingdom are the ....., ..., ... and .....
62. The five great groups of the vertebrates are the ....., ..., ..., ... and .....

GENERAL SCIENCE TEST, NO. I.

Fill in the blank spaces with the words which will make the sentences correct and complete.

1. Water can be composed into ..... and ..... by means of .....
2. The ..... in gas and the ..... in air unite in burning to form steam.
3. The water molecule is made up of two kinds of .....
4. A substance with only one kind of ..... in the molecule is called an ....., but a substance with only two or more kinds is called a .....
5. Smoke is composed of fine particles of .....
6. When carbon burns in oxygen it forms ....
7. The bubbles in soda water are composed of ....
8. ..... are the original source of all foods for man.
9. Starch and sugar are composed of ....., ... and .....
10. Starch is made in a ..... from ..... and ....
11. The blade of a ..... contains a network of .....
12. A leaf stalk is called a .....
13. The blades at the base of a leaf stalk are called .....
14. A leaf blade is covered by its .....
15. The two tissues of the mesophyll are the ..... tissue and the ..... tissue.
16. Carbon dioxide gets into a leaf through the ..... in the lower .....
17. Tissues are composed of .....
18. The green coloring matter in a leaf is called .....
19. The green granules in the leaf cells are called .....
20. The process by which the ..... of ..... plants, with the aid of ....., manufacture carbohydrates out of ..... and .... is called .....
21. The living plants in dust are of three kinds ....., ... and .....
22. The preservation of food by the use of such substances as ....., ..., and ..... is common and effective.
23. ..... is most commonly used to kill living things in food.
24. Milk may be pastuerized by heating for ..... minutes between ..... and .....
25. Typhoid fever can be reduced by ....., killing ....., and proper ..... disposal.
26. Malaria and yellow fever are carried by ..... The four stages in the life of a fly are ....., ..., ..., ...
27. Malaria is caused by a one-celled .....

GENERAL SCIENCE TEST NO. II.

Underscore the word after the dash which most correctly completes the sentence.

1. Air is an—element, compound, mixture.

2. Water is an—element, compound, mixture.
3. Hydrogen is an—element, compound, mixture.
4. Oxygen is an—element, compound, mixture.
5. Wax is an—element, compound, mixture.
6. Carbon is an—element, compound, mixture.
7. Carbondioxide is an—element, compound, mixture.
8. The gas most abundant in air is—carbondioxide, argon, nitrogen, oxygen.
9. Cider is changed into vinegar by—yeasts, molds, bacteria.
10. Apple juice is fermented to cider by—yeasts, molds, bacteria.
11. Such diseases as tuberculosis and typhoid fever are caused by—yeasts, molds, bacteria.

Some of these sentences are true, others are false. Mark the true ones T, and the false ones F, at the end.

1. Any change in a substance in which the molecule is changed by atoms being taken away from it, added to it, or exchanged for others is called a chemical change.
2. A change from solid to liquid or from liquid to gas or vice versa without changing the number of atoms in the molecule is called a physical change.
3. When starch is blackened by heat the change is physical.
4. When water is changed to steam by heat the change is chemical.
5. Carbon dioxide makes lime water turn milky.
6. Carbon dioxide is lighter than air.
7. Carbon dioxide burns with a yellow flame when air is not mixed with it.
8. Illuminating gas is a mixture of hydrogen and carbon monoxide.
9. Oxygen is the most abundant element on earth.
10. Nitrogen burns with a hot flame.
11. A plant gets its water from the soil and its carbon dioxide from the air.
12. Oxygen is the waste product in the process of photosynthesis.
13. Oils and proteins are not manufactured by plants.
14. It is safe to sterilize milk with formaldehyde.
15. Mosquitoes breed in water.
16. Yellow fever is carried by an insect called Stegomyia.
17. Rats and fleas spread the plague.
18. Body lice spread Asiatic cholera or typhus.
19. Water contracts evenly and continuously from 212° F. to 32° F.
20. Water increases in volume from 1°C to 0°C.
21. Ice is lighter than water.
22. Water boils at a lower temperature at Bluefield than at the seashore.
23. Eggs boiled 3 minutes at Auito, Ecuador, are boiled harder than eggs boiled three minutes at the seashore.
24. Steam is a transparent, colorless gas.
25. Ice, water, and steam are different substances.
26. When salt water is boiled and the steam is condensed to water the condensed steam is not salty.
27. Distillation is a process used only for making alcoholic liquors.
28. Glass and wax do not have a definite melting point.
29. Perspiration heats the body.
30. Transpiration is the evaporation of water from plants.
31. Atmospheric pressure raises water in the siphon.

General Science Test—First Semester.

Fill in the blanks in the following sentences with the correct words.

1. Air pressure is measured by a .....
2. Air temperature is measured by a .....
3. One centigrade degree equals = ... times as much as a Fahrenheit degree.
4. Zero on the centigrade scale ..... on the Fahrenheit scale.

5. 212° F = ... ° C.
6. The air pressure is .... at Bluefield than at the seashore.
7. Heated air is ..... than an equal volume of cold air.
8. ..... humidity is amount of moisture in the air.
9. ..... humidity is found by dividing the amount of moisture in the air by the amount of moisture the air could hold.
10. The temperature at which the moisture in the air begins to condense to water is called the ..... point.
11. When air is heated it ..... the relative humidity.
12. Air pressure is measured by the number of inches or millimeters of ..... that it balances.
13. The warmer air is the ..... water vapor it can hold.
14. A current of water or air caused by unequal heating is called a ..... current.
15. A ray of light strikes a ..... surface of the earth at noon than at sunrise or sunset.
16. In summer the days are ..... the farther you go from the equator toward the pole.
17. The days are ..... in December than in June north of the equator.
18. The nights are ..... in December than in June south of the equator.
19. During our winter the ..... hemisphere is tilted toward the sun.
20. On March 21 and September 22 the days and nights are .....
21. Sunlight heats the earth ..... than the air.
22. A line connecting points of equal temperature is called an .....
23. A line connecting points of equal pressure is called an .....
24. The movement of air counter clockwise around an area of low pressure is called a .....
25. A violent storm in which the movement of the air resembles that of water in a whirlpool and follows a narrow path is called a .....
26. A great movement of air clockwise around a center of high pressure is called an .....
27. We are in the belt of ..... winds.
28. In the Rocky Mountains most of the rain falls on the ..... side of the ..... side of the mountains.
29. The smallest possible particle of a substance is called a .....
30. When the smallest particles are separated and moving freely except for hitting each other and bouncing off a substance is called a .....
31. When the smallest particles touch each other but slide over each other easily a substance is called a .....
32. When the smallest particles are packed closely together so that they can not slide a substance is called a .....
33. Heat ..... the pressure of an inclosed volume of gas.
34. The property that gases or liquids have of mingling when in contact with each other is called .....
35. There are ..... between the particles of all things.
36. Molecules are made up of .....
37. A substance whose molecules can not be separated into two or more simpler substances is called an .....
38. A change in a substance involving the breaking up of the molecules, or the addition of something to the molecules so as to make different molecules is called a ..... change.
39. A change in a substance which changes only the distance between the molecules is called a ..... change.
40. Water, wax, carbon dioxide and starch are .....
41. Iron, oxygen, nitrogen, mercury, and carbon are .....
42. Air is a ..... of nitrogen, oxygen, argon and carbon dioxide.
43-47. The process in which the ..... of green plants, with the aid of ....., manufacture ....., out of ..... and .... is called photosynthesis.
48. ..... is the waste product in photosynthesis.

49. Plants which manufacture foods containing nitrogen are called .....
50-52. The three living things in the dust of the air are ....., ..., and .....
53. A plant that lives on dead plant or animal matter is called a ....
54. Corn smut is a .....
55. ..... cause bread dough to rise.
56. Pneumonia, typhoid fever, diphtheria and colds are caused by .....
57-58. Grippe, diphtheria, colds, tuberculosis and typhoid fever enter the lungs or alimentary canal through the ..... or.....
59. Typhoid germs in water can be killed by .....
60. Typhoid germs in milk may be killed by .....
61. Typhoid germs are often carried by .....
62. Malaria is caused by a one-celled .....
63. Malaria germs are carried from person to person by .....
64. The bubonic plague is spread from rats to people by .....
65. Water freezes at ..... degrees F.
66. Water boils at ..... degrees F.
67. Increasing the pressure ..... the boiling point.
68. Water may be freed from salt by .....
69. Evaporation ..... the temperature.
70. The passing off of water by plants is called .....
71. Water can not be raised more than ..... feet, by means of a siphon.
72. The difference in ..... of the two columns of liquid starts the siphon to flow.
73. The hydraulic press works because of the ..... of pressure in liquids.
74. Any object immersed in a liquid loses a weight equal to the ..... liquid displaced.
75. The density of a substance is the ..... of a cubic centimeter of it.
76. An iron ship is as ..... as the volume of water it displaces in floating.
77. A cubic centimeter of water weighs a .....
78. The ..... shore of Lake Michigan has the best climate for growing peaches.
79-80. Lakes and oceans tend to ..... the temperature over the nearby land in summer and to ..... the temperature in winter.
81. On a hot day there is usually a ..... from the water to the land.
82-83. A cave or mine is ..... than the outside air in summer and ..... in winter.
84. Water heats and cools more ..... than earth.
85-86. The two main kinds of waterways are ..... waterways and ..... waterways.
87-89. The three kinds of impurities in water are ....., and ....., and ....
90. Gases are prevented from getting into houses from sewage pipes by means of .....
91. Water is hardened by ..... in the water.
92. The ..... in water often cause disease.
93. The Bluefield water is sterilized by adding .....
94-99. The six simple machines are the ....., ..., ..., ..., ... and .....
100. The useful work out divided by the total work in gives the .... of a machine.

THE DEVELOPMENT OF RADIO COMMUNICATION.

By L. A. Hazeltine,

Professor of Electrical Engineering, Stevens Institute of Technology.

(Condensed from address at meeting of the New Jersey Science Teachers' Association at Stevens Institute of Technology, May 13, 1922.)

In introducing my subject before the science teachers of New Jersey, it is particularly appropriate to refer to the fact that the first person to knowingly produce an electric oscillation and to detect its effects at a distance was a science teacher of New Jersey—Professor Joseph Henry, then (1842) at Princeton.

The oscillatory discharge of a condenser through an inductive circuit and the production thereby of electric waves, then achieved by Henry, were later to constitute the foundation of Hertz's scientific researches on electric waves and Marconi's development of radio telegraphy, and today are employed by the greater number of ship and amateur radio transmitting stations.

Henry was also an independent discoverer of the fundamental phenomenon of electromagnetic induction (following Faraday by only a few months, 1831-32), was the first to discover self-induction, deserves the major credit for the wire telegraph, and laid the foundation on which the alternating-current transformer was built. All of these are of prime importance in radio communication.

The keynote of radio is the electric wave. What is its true geneology? Marconi made it useful, but he built on the experiments of Hertz, who employed the formulations of Maxwell, who in turn based his theories on the conceptions of Faraday.

Faraday's greatest contribution was *a point of view*. Where his contemporaries saw only material conductors and magnets, Faraday saw magnetic and dielectric fluxes (his "lines of force") extending throughout space. He not only saw them, but he told how to measure them and he determined their laws—such a foundation did he lay that it has never needed alteration or addition! All electrical engineering is built on it.

Maxwell "popularized" Faraday's ideas in a strange way. He clothed them in mathematical dress to suit the taste of the mathematical physicists of his day. But clothing another person's child was not his major achievement. He showed that the ideas of Faraday lead inevitably to the conclusion that

electromagnetic effects could be propagated as waves through space; and he advanced the idea that light was in fact such an electromagnetic wave phenomenon (1865). He calculated the theoretical velocity of an electromagnetic wave and showed that it agreed with the measured velocity of light—the best proof we have of their identity.

Hertz gave reality to Maxwell's wave theory by producing electric waves in an electrical way (1888). He reflected, refracted and absorbed them, like light waves, and measured experimentally their velocity.

Marconi adapted electric waves to communication purposes, primarily by arranging his oscillator vertically, so that the waves could travel along the surface of the earth (1895). And he made his oscillator large enough and powerful enough to transmit detectable power to great distances.

To sum up, the dynasty consisted of Faraday, who supplied the raw material, Maxwell, who provided the tools, Hertz, who made the machine, and Marconi, who adapted the machine to the service of man.

A few years ago it was the universal fashion to describe electric waves and light by reference to an *ether*. Today there is a growing school who feel like a colleague of mine in considering that "ether" is an example in the English language of a word without any corresponding idea. It seems that the notion of an ether came from a false extension of the analogy of light to sound; both consist in the transfer of a vibration progressively from point to point in space; but the analogy stops there. Sound is a vibration of material particles and so requires a medium; while light is a purely electrical vibration and requires magnetic and dielectric fluxes for its propagation, but no necessary medium. Let us quote Faraday's ideas on this point:

"The view which I am so bold as to put forth considers, therefore, radiation as a high species of vibration in the lines of force which are known to connect particles and also masses of matter together. It endeavors to dismiss the ether, but not the vibration."

These words, written in 1846, anticipate (but without demonstration) Maxwell's electromagnetic theory of light and even the most recent views.

Let us now consider electric oscillations and waves by reference to familiar analogies in mechanics. Oscillations occur in bodies by virtue of their *inertia* and their *elasticity*. Inductance is electrical inertia and capacity is electrical elasticity: hence

electrical oscillations can occur in circuits having these properties. When the inertia and the elasticity of a material body or medium (as air) are distributed throughout space, the mechanical oscillation takes the form of a wave, such as a sound wave. Correspondingly, when inductance and capacity are distributed (as they are in any insulating space, including a vacuum) the electrical oscillation takes the form of an electrical wave.

The electric oscillations of Hertz and of Marconi's early experiments were produced by the electrical breakdown of a spark gap, which allowed a previously charged condenser to discharge through an inductive circuit, and were so rapidly damped as to be almost impulsive. The analogy is a tank into which air is pumped until it bursts and radiates a sound wave as a "bang." Marconi detected his impulsive electric wave by the breakdown of the insulation in a coherer, thus closing a local circuit through a relay; and to restore the coherer preparatory to receiving the next impulse, he regularly tapped it. Similarly we might detect an explosive sound by the bursting of a soap bubble (as window panes are sometimes burst at a distance from a severe explosion), and we might regularly blow new bubbles to detect subsequent sounds.

The introduction of electrical tuning (largely through the work of Pupin) permitted selection between electric waves of different frequency. The oscillations at the transmitting circuit were then made slowly damped, and the receiving circuit had its inductance and capacity adjusted to give it the same natural frequency, with the result that it was strongly affected by the desired signal and but weakly affected by interfering signals of other frequencies. The analogy is a tuning fork which when struck will produce a slowly damped oscillation and will affect a second tuning fork in its neighborhood, provided this has the same natural frequency or pitch.

Later *continuous* (or "undamped") electrical oscillations were introduced for radio communications (as initiated by Fessenden). These are produced in three ways: (a) by direct generation (Alexanderson, alternator); (b) through the electrically unstable arc (Poulsen); and (c) by the three-electrode vacuum tube with the feed-back circuit (Armstrong).

The direct generation of high-frequency current may be likened to the mechanical production of sound by the interrupted air jet of the siren or by the telephone receiver supplied with alternating current.

The conversion of direct current into alternating current by virtue of the unstable action of the electric arc is analogous to the conversion of a steady air stream into a sound vibration through some form of instability at the mouthpiece of a wind musical instrument.

The story of the three-electrode vacuum tube and its application in the production, detection and amplification of radio signals is too long to be more than touched on, for it would include nearly all of modern radio and much of the recent advance in electrical science. Edison discovered the phenomenon of one-way electric conduction through the space between the hot filament of an incandescent lamp and a second electrode inside the lamp. Fleming introduced such a two-electrode vacuum tube into the radio art, and thus provided an electric valve to convert the interrupted high-frequency received current into an interrupted direct current that could actuate an ordinary telephone receiver. When DeForest added the third electrode, the grid, as a control member, he opened a new field; for the received signal energy was thereby no longer required to actuate the telephone receiver directly, but merely to *control* a local source of practically unlimited energy (the plate-circuit battery). It was like the substitution of an electric motor for manual labor; it still takes some work to close and to open the switch that controls the motor, but far less than that which may be done by the motor. The three-electrode tube thus has an amplifying action, giving out electric energy of a desired form under the control of a minute input energy; this action may be, and is, employed in other fields besides that of radio communication.

Armstrong took advantage of the amplifying property of the three-electrode vacuum tube to feed back some of the output energy into the input, or control, circuit. This would reinforce any oscillation that might be present in the input circuit, and if powerful enough would maintain a continuous oscillation without any impressed signal or other help. Thus was achieved the vacuum tube oscillator, now universally used for radio telephone transmitting and likely to supplant the other methods for all radio transmission.

The vacuum tube oscillator is essentially a self-controlled electric valve which converts the direct current of a battery or a generator into an alternating current, thus being the converse of the rectifier. A mechanical analogy is the steam engine,

which receives a continuous flow of steam and converts it into a reciprocating motion through the appropriate operation of its valves. Just as the valves of the steam engine are actuated through mechanical coupling by the motion of the piston which they effect, so the grid of the vacuum tube is actuated through electrical coupling by the alternating current which it causes.

A closer analogy to the oscillation of a vacuum tube is the "howl" produced when the telephone receiver of a house set is placed in front of the transmitter. Here any sound impulse which actuates the transmitter will be carried electrically to the receiver, which in turn will send a sound wave into the transmitter, the action being cumulative and being maintained by the battery in the circuit.

ORAL VERSUS WRITTEN INSTRUCTION AND DEMONSTRATION VERSUS INDIVIDUAL WORK IN HIGH SCHOOL SCIENCE.

By J. L. Cooprider,

Central High School, Evansville, Ind.

Much time recently has been devoted to the problems relating to the teaching of school subjects more efficiently. Many methods have been discussed, and, to a very small degree the effectiveness of the instruction has been objectively measured. It seems that more "talking" has been done than "objectively measuring," the later of which seems to be the real key to a determination of efficiency. It is with these ideas that this study is presented.

In this study an attempt was made to determine the relative values of oral and written instruction and the relative values of demonstration and individual work in laboratory work in high school science. The data for this study was secured by giving twenty-four laboratory exercises to forty-two students in a class of biology of sophomore grade in high school. The first problem was to grade the pupils according to their mental ability. This was done by giving the "Chicago Group Intelligence Test" devised by F. N. Freeman and H. O. Rugg. As a result of this test, the students were placed in three sections of fourteen students in each section. The average ability for each of the three sections was 48.21 as shown by the intelligence tests. The average school grade for the three sections was 82.88 per cent; 82.97 per cent; and 82.42 per cent respectively. These school grades vary but little and add weight to the fact that the students were divided into sections of nearly equal ability.

In securing the data for this study four methods were used, namely, demonstration with oral instructions, demonstration with written instructions, and individual work with oral instructions, and individual work with written instructions. In the demonstration work with oral instructions, the instructions for working the exercises were given orally by the instructor and the exercises were performed by the instructor immediately. In the demonstration work with written instructions, the instructions, in typewritten form, were handed to each student, who read them, then the instructor performed the exercises. In the individual work with oral instructions, the instructions were given orally by the instructor and the students performed the exercises at once. In the individual work with written instructions, each student read a copy of the typewritten instructions, and then proceeded to work the exercise. The instructions for working the exercises were the same in each of the four methods referred to above. The method of presentation was the only thing that varied.

The students' record for each exercise was divided into four divisions, namely, object, procedure, results and conclusion. Under "object" the student simply stated the purpose of the exercise given in the instructions, memory being a large factor here. Under "procedure" the student tabulated, step by step, the things that were done in working the exercise. Under "results" the student recorded the observations he made as a result of the procedure. The "conclusion" was a summary of the thing to be proven, tested, or learned, and in most cases it called for reasoning. After the exercise had been performed by any method, each student was given a piece of paper upon which he wrote up the exercise under each of its four divisions.

The student's record was scored by using both the point and the percentage systems. Each student was scored first by the use of points, which were then reduced to percentage. The number of points for each division of the exercise was determined by the instructor. A total score for each student was found by dividing the sum of the per cents in the four divisions of the exercise by four. This made the *memory factor* of the "object," the *manipulation factor* of the "procedure," the *observation factor* of the "results," and the *reasoning factor* of the "conclusion" of equal weight.

In scoring the papers one point was scored at a time in all of the sections. Since the time required for marking each point

was not longer than ten minutes, the possibility of irregular marking was eliminated. At the time of scoring, errors were indicated on the paper so that the student might have a correct note-book record of the exercise performed. In this way the student was aware that his papers were being carefully marked and that his accuracy in every case affected his grade. Thus the very best attention of the student was demanded at all times. However, this arrangement eliminated the testing of results at some time after the exercise had been performed.

Different types of exercises were selected which might be divided into four classes: (1) Some exercises attempted to clear up some problem with which the student was already somewhat familiar and which required no reasoning to the conclusion. (2) Some exercises demanded careful observations and discriminations in order to reach the conclusion. (3) Some exercises gave the student a problem in which reasoning to the conclusion was necessary. (4) Some exercises presented a problem involving the memory of former exercises and also reasoning to the conclusion.

In selecting exercises for the data of this study, it was planned to select typical exercises in biology. It was not the idea to select exercises the student might term "easy," thus destroying his interest in the exercise. In some of the exercises two or three of the "familiar types" of exercises were combined, thus eliminating the possibility of the exercises being too "common." By this selection, then, the student's interest and attention was sufficiently aroused that he kept the procedure in mind, was accurate in observation, and exercised a keen judgment. In selecting exercises for this study it was also necessary to select exercises that could be performed by any of the four methods. The following are some of the exercises used: The iodine test for starch, Fehling's test for grape sugar, the nitric acid test for protein, tests for acids and bases, the action of diastase on starch, capillary inbibition, the effect of evaporation on plants, and to find the changes that take place when seeds grow.

The results of this study were tabulated under two headings: (1) The oral versus written instructions in both demonstration and individual work, and (2) demonstration versus individual work with both oral and written instructions. In the four tables given below there is a comparison between the methods indicated. We shall now briefly consider these results.

In twelve of the twenty-four exercises the instructions for working the exercises were oral and in twelve they were written. Of the twelve exercises with oral instructions six were performed by demonstration and six by individual work. Of the twelve exercises performed with written instructions six were performed by demonstration and six were performed by individual work. For ease of comparison it would have been better if there had been four sections of students instead of three sections. This would have made one section for each of the four methods. But since there were three sections, there was one set of results in one of the four methods with which there was no comparison. In making comparisons between any two methods, the results of one of the three sections were eliminated in order that there might not be the factor of variation within the exercises themselves. This elimination accounts for the fact that the results of only twelve exercises appear in each of the tables below.

TABLE I. COMPARISON BETWEEN ORAL AND WRITTEN INSTRUCTION IN EXERCISES PERFORMED BY DEMONSTRATION.

Exercise No.	Object		Procedure		Results		Conclusion		Totals	
	Score in %		Score in %		Score in %		Score in %		Score in %	
	Oral	Writ.	Oral	Writ.	Oral	Writ.	Oral	Writ.	Oral	Writ.
3	92.9	85.7	94.9	86.7	92.9	92.9	7.1	7.1	71.9	68.1
4	84.6	64.3	92.3	88.9	76.9	64.3	19.2	10.7	68.3	57.4
5	100	100	87.5	83.1	42.8	42.8	50	28.6	70.1	63.6
6	100	100	89.8	87.7	100	100	64.3	64.3	88.5	88.1
8	100	100	90.5	89.3	78.6	78.6	50	42.9	79.7	77.7
11	100	92.9	86.6	88.6	92.9	85.7	50	57.2	82.9	81.1
13	78.6	57.2	85.7	87.7	76.2	76.2	21.4	00	65.4	55.4
14	78.6	92.9	85.7	75.5	69.1	73.8	14.3	7.1	61.9	62.3
17	92.3	100	96.2	93.8	88.5	92.9	61.5	28.6	84.6	78.8
20	92.9	92.3	88.1	82	77.5	82.4	71.4	100	82.5	89.4
23	69.2	53.9	94.2	94.1	92.3	84.6	61.5	15.4	79.3	62.0
24	92.9	92.9	87.5	86.6	28.6	10.7	21.4	14.3	57.6	51.1
Av.	90.2	86.1	90.1	87.0	76.4	73.8	41.0	31.4	74.4	69.6

In Table I there is a comparison between the oral and the written instructions in exercises performed by the demonstration method. In Table II there is a comparison between oral and written instructions in exercises performed by the individual method. We see that in every division of the exercise as well as the total averages of these four divisions that the averages for the exercises with oral instructions are higher than the averages for the exercises with written instructions.

From Table I we see that the average of the "totals" is 74.4% in the work with oral instructions, and 69.6% in the work with written instructions. There is a difference of 4.8% in favor of the oral instruction. In the totals of the twelve exercises there are only two exercises (14 and 20) in which the averages for the work with written instructions are higher than the averages of the work with oral instructions.

TABLE II. COMPARISON BETWEEN ORAL AND WRITTEN INSTRUCTION IN EXERCISES PERFORMED BY INDIVIDUAL WORK.

Exercise No.	Object		Procedure		Results		Conclusion		Totals	
	Score in %		Score in %		Score in %		Score in %		Score in %	
	Oral	Writ.	Oral	Writ.	Oral	Writ.	Oral	Writ.	Oral	Writ.
1	71.4	21.4	86.5	83.4	96.4	96.4	82.1	67.9	84.1	67.3
2	92.9	64.3	78.6	80.9	62.5	51.8	50	50	71	61.7
7	100	100	88.6	88.6	78.6	73.8	57.2	50	81.1	78.1
9	100	100	92.8	96.9	85.7	64.3	50	28.6	82.1	72.4
10	96.4	96.4	90	91.4	75	78.6	50	14.3	77.9	70.2
12	96.4	85.7	95.7	91.4	88.1	65.2	23.2	21.4	75.9	66.3
15	92.9	85.7	77.3	67.9	92.9	89.3	7.1	00	67.6	61.7
16	100	53.9	91.1	89.7	89.3	96.2	28.6	15.4	77.2	63.8
18	92.3	92.3	82	72.6	56.4	61.9	46.2	42.9	69.2	67.6
19	100	78.6	73.8	79.8	72.6	66.7	57.2	57.2	75.9	70.5
21	100	100	86.3	83	85.7	46.4	35.7	28.6	76.9	64.5
22	76.9	69.2	71	60.3	56.9	56.9	76.9	84.6	70.4	67.8
Av.	93.3	79.0	84.5	82.2	78.3	70.6	47.0	38.4	75.8	67.7

TABLE III. COMPARISON BETWEEN DEMONSTRATION WORK AND INDIVIDUAL WORK WITH ORAL INSTRUCTIONS.

Exercise No.	Object		Procedure		Results		Conclusion		Totals	
	Score in %		Score in %		Score in %		Score in %		Score in %	
	Dem.	Indiv.	Dem.	Indiv.	Dem.	Indiv.	Dem.	Indiv.	Dem.	Indiv.
1	85.7	71.4	81.0	86.5	100	96.4	75.0	82.1	85.6	84.1
3	92.9	85.7	94.9	87.7	92.9	92.9	7.1	57.2	71.9	80.9
6	100	92.9	89.8	89.8	100	92.9	64.3	71.4	88.5	86.8
8	100	100	90.5	97.6	78.6	89.3	50	58.1	79.7	86.1
10	85.7	96.4	88.6	90	82.1	75.0	50	50	76.6	77.9
11	100	100	88.6	87.1	92.9	82.1	50	85.7	82.9	88.8
14	78.6	71.4	85.7	82.7	69.1	81.0	14.3	28.6	61.9	65.9
16	85.7	100	92.3	91.1	89.3	89.3	7.1	28.6	68.6	77.2
18	85.7	92.3	78.6	82.0	52.4	56.4	50	46.2	66.7	69.2
19	78.6	100	77	73.8	78.6	72.6	71.4	57.2	76.2	75.9
22	92.3	76.9	73.4	71	63.1	56.9	76.9	76.9	76.4	70.4
23	69.2	53.9	94.2	94.6	92.3	78.6	62.5	21.4	79.3	55.8
Av.	87.9	86.7	86.2	86.2	82.6	80.3	48.1	55.3	76.2	76.6

In Table II the average for the "totals" in the work with oral instructions is 75.8%, and for the work with written in-

structions it is 67.7%. The difference here is 8.1%, also, in favor of the work with oral instructions. In each one of the twelve exercises the average for the work with oral instructions is higher than the average for the work with written instructions.

It is noted that in comparing the averages for the "totals" of the four methods that the individual work with oral instructions ranks the highest. The second in order in the demonstration work with written instructions. The third in order is the demonstration work with written instructions. The lowest average is in the individual work with written work.

TABLE IV. COMPARISON BETWEEN DEMONSTRATION WORK AND INDIVIDUAL WORK WITH WRITTEN INSTRUCTIONS.

Exercise No.	Object		Procedure		Results		Conclusion		Totals	
	Score in %		Score in %		Score in %		Score in %		Score in %	
	Dem.	Indiv.	Dem.	Indiv	Dem.	Indiv.	Dem.	Indiv.	Dem.	Indiv.
2	71.4	64.3	88.7	80.9	53.6	51.8	35.7	50.0	62.3	61.7
4	64.3	82.1	88.9	88.9	64.3	64.3	10.7	10.7	57.4	61.5
5	100	92.9	83.1	83	42.8	39.3	28.6	28.6	63.6	60.9
7	85.7	100	91.4	88.6	71.4	73.8	35.7	50.0	70.1	78.1
9	100	100	93.8	96.9	67.9	64.3	42.9	28.6	76.1	72.4
12	96.4	85.7	90.0	91.4	85.7	65.2	25.0	21.4	74.3	66.3
13	57.2	42.9	87.7	80.5	76.2	59.5	00	00	55.3	45.7
15	85.7	85.7	61.9	67.9	67.9	89.3	21.4	00	59.2	61.7
17	100	100	93.8	93.8	92.9	75.0	28.6	14.3	78.8	70.8
20	92.3	92.3	82.0	80.8	83.4	79.1	100	84.6	89.4	84.2
21	92.9	100	92.3	83.0	92.9	46.4	42.9	28.6	89.5	64.5
24	92.9	85.7	86.6	90.2	10.7	25.0	14.3	7.1	51.1	52.0
Av.	86.6	86.0	86.7	88.8	67.5	61.1	32.2	27.0	68.9	65.0

In Table III there is a comparison between the demonstration and individual work with oral instructions. In Table IV there is a comparison between the demonstration work and the individual work with written instructions. At first glance at the results it seems that there is not much in favor of either the demonstration or the individual work, but let us make a brief survey of the results to see just what are the differences.

In Table III we see that the average in the "totals" for the demonstration work is 76.2% and that of the individual work is 76.6%, making a difference of only 0.4% in favor of the individual work. In Table IV the average in the "totals" for the demonstration work is 68.9% and for the individual work it is 65.0%, making a difference of 3.5% in favor of the demonstration work. In the work with oral instructions (Table III) there are eight exercises in which the averages for the individual

work are higher than the averages for the demonstration work. In the work with written instructions (Table IV) there are eight exercises in which the averages for the demonstration work are higher than those of the individual work. These results are about the same, but the demonstration work seems to be a little better.

The amount of time consumed by the classes working the exercises by the individual method was about twice that required by the demonstration method. This would be a decided advantage for the demonstration method. If the results of the demonstration work and the individual work are nearly the same, then, it seems that the demonstration work would not only be a time-saving device but also a great saving in the purchase of extra laboratory equipment necessary for individual work.

A few other results are noticed from the above tables other than the comparison of the four methods. It is noticed that the average scores for the "object," "procedure" and the "results" divisions are fairly high in all methods as compared with the average in the "conclusion" division. We have pointed out above that the students' tabulation in the "object" involved largely memory; that the "procedure" involved largely manipulation of apparatus; that the "results" involved largely observation on the part of the pupil; and, that the "conclusion" involved largely reasoning. If these assumptions are correct, and they are to a certain extent, then, our present methods of science instruction fall short in teaching the student to reason scientifically, whereas memory plays a leading role, and we have succeeded fairly well in training the pupil in observation and in the manipulation of apparatus.

To summarize the conclusions reached in this study, the following points were brought out: (1) Exercises with oral instructions give better results than exercises with written instructions in both demonstration and individual work. (2) Individual work with oral instructions is more efficient than demonstration work with oral instructions. (3) Demonstration work with written instructions is more efficient than individual work with written instructions. (4) Demonstration work is better than individual work. (5) Our present methods of science instruction fall short in teaching the pupil to reason scientifically.

THE NEED OF A GENERAL COURSE IN MATHEMATICS.[1]

By Myrtie Collier

Assistant Professor of Mathematics, University of California, Southern Branch.

The subject of the evening, The Need of a General Course in Mathematics, may well be considered under three general headings:

1. The work preceding the general course.
2. The content of a general course, and the advantages of a course of this type over the more formal type of applied arithmetic in the seventh and eighth grades, followed by algebra or demonstrative geometry in the ninth grade.
3. The preparation such a course offers for the mathematics following the general course.

I shall try to outline the first point definitely, to discuss the second point briefly, and to leave the third for the conference discussion.

You high school teachers have a right to expect of the student coming to you in the ninth grade a clear understanding and a working knowledge of the four fundamentals in whole numbers, and in fraction; the ability to think in decimals; I mean by this that the student's concept of decimals be something more than the fact that one decimal point is to be placed over another decimal point in the division of decimals. He should know, for example, that units, regardless of the number of decimal places following the digit in units place, will give a unit in the quotient when divided by a unit less in value than the digit in unit's place in the dividend; but when divided by a unit greater in value the quotient will yield a tenth for the first digit, etc., thus: 4)7.38(1., 8)7.3897(.9.

This is pure number relation, and a knowledge of number relation is what a study of arithmetic is supposed to give to the child. Furthermore he should be able to think in the particular number relation of per cent as applied to his everyday experiences in grading papers, school attendance, simple money transactions, etc., and to know the numbering involved in the usual standard weights and measures.

Added to this quantitative thinking, the student should know how to construct simple problems, and how to attack and how to solve problems. In other words, his eight years of mathematics preceding the time he reaches you should have made him an independent thinker along the very simple lines

[1]Read before the Southern California Science and Mathematics Association, Los Angeles, Calif., March 31, 1922.

of the social and civic aspect of mathematics outlined above. But you say he is not. There are three main reasons why he is not. The first reason is that the pupil is given so much useless material that the usable is lost in the mass. The committee on Minimum Essentials in Arithmetic found through its investigation that the business world is not using much of the material found in the textbooks. This same committee recommended the elimination of much of the work now given, that greater stress may be placed upon the essentials which were defined to be a high degree of accuracy in:

1. Addition of five addends, five digits wide.
2. Subtraction, five digits wide.
3. Multiplication, with a multiplicand of five digits and a multiplier of four digits.
4. Division, with a dividend of five digits and a divisor of four digits.
5. Addition, subtraction, and multiplication of the following fractions: halves, thirds, fourths, fifths, eighths, and tenths.
6. Decimal fractions of three places.
7. Simple interest.
8. Cash accounts, and children's and family's expense accounts.
9. Cash checks and bills.
10. Banking.

A second reason for this lack of preparation is that the pupil is taught in such a way that he is not led to think for himself, but is told either by the textbook or the teacher how to do everything; this makes him an imitator instead of an independent thinker. The third reason is that through a lack of diagnostic tests much of the pupil's time and energy spent on drill, is misdirected, and therefore lost. For a pupil to discover that he is weak in multiplication, for example, does not tell him or the teacher just what point is in need of remedial treatment. He must be led to discover which particular combination, if one, is most difficult for him; or if his trouble lies in the "carrying" process in the multiplication; or in placing the partial products as addends; or if it is in adding the partial products; or in the use of the 0 in the multiplicand or the multiplier.

Our second point, the general course in mathematics—must be thought of in question form, there being three main questions: First, what shall be the content of such a course? Second, shall such a course be required of all pupils? Third, what are the advantages of a course of this type over the more formal work of straight algebra and demonstrative geometry.

I am sure that all of you high school teachers have kept so closely in touch with the National Committee on Mathematical Requirements that you have well in mind the proposed content of the Junior High School course in mathematics, namely:

Some arithmetic,
Some algebra,
Some intuitive geometry,
Some numerical trigonometry,
With possibly some demonstrative geometry.

Here we have the basic material necessary for a general course. It is left to the teacher or the textbook to make the correlation. Mr. Breslich, of the University High School of the University of Chicago, is working out a course of correlated mathematics for the seventh and eighth grades. May I suggest here that it is well to leave the making of mathematical textbooks to the mathematician. Professor Snedden is quite right in his statement that "Educational administrators have allowed specialist advocates, with their *ex parte* pleadings, to play too large a part in determining curricula." On the other hand, we have already observed enough to be aware of the danger of allowing the making of textbooks in mathematics to be taken out of the hands of mathematicians and placed in the hands of the educators.

Personally I feel that much time is more than wasted in the seventh and eighth grades in mathematics. The report on the tests given the men in the army bears out this belief. The men who had had only six years of training did as well as those who had eight years. The tests in our schools show this in many cases. What is needed is to complete arithmetic, as such, in the sixth grade, to begin the correlated mathematics in the seventh grade, and continue it through the eighth grade.

Such a course should include the practical application of number to the civil and social aspect of mathematics, family budget, household accounts, saving, simple interest, incomes on a few safe investments, simple bank transactions, saving accounts, checking accounts, the interpretation of insurance, and the construction and use of graphs, the measuring or study of space relations. It should also include the study of algebra, involving a working knowledge of the simple equation as a means of a *further study* of number relations, and of the interpretations of space relations; the ability to derive the underlying relations of the formula, and to use the formula as a time saving device. Through such a study of relationships the function concept will be developed.

If such a course is offered in the seventh and the eighth grades, it becomes a question whether a similar course is needed in the ninth grade. Or would it be better to give less time to this

work in the seventh and eighth grades and stress it in the ninth grade? (Mr. Shorling has said that we are fast becoming a "ninth grade nation." If so, perhaps this work should receive its due attention in the ninth grade.) The point that I am trying to make here is that we have no time for mathematics in the elementary or secondary school if that mathematics is not to function in the child's interpretation of his surroundings or environment. Such a course as outlined above is needed by the pupil if he takes any science work in the high school.

We have no time to learn a thing for the thing's sake. Doubtless we all agree that the average American citizen needs a working knowledge of number as outlined above; could use to advantage a knowledge of the simple equation and of the formula; and needs to interpret and relate space relations. No one of these three points appears wholly by itself. They are all related. Why separate them in school and name one arithmetic which is offered to all, another algebra which is offered to the select few, and another geometry for the limited few? Algebra and geometry are not so widely separated. They supplement each other, and at the same time clarify and deepen the pupil's comprehension of quantity or number relations.

A subject should be learned as it is to function. I went to the physics department, the chemistry department, the biological science department, and to my colleagues in the mathematics department, and asked them to make a definite statement, in so far as they could, as to what it was that their freshmen students lacked in mathematics. In every instance the reply was that the student is unable to apply his mathematical knowledge—it does not function—he sees too little connection between his mathematics and his environment.

May I quote directly from the physics department: "Students have difficulty in associating the abstract magnitudes of algebra and geometry with the physical magnitudes of practical problems. The angle is the difference of direction of two lines meeting in a point; but it has nothing to do with the amount of rotation of a body about an axis. The student seems to have learned formulas as formulas instead of physical relations. Young's modulus = FL/AE where F/A = unit stress, and E/L = unit strain.

The ratio of unit stress to unit strain is FL/AE.

Furthermore "he lacks facility in fundamental algebraic operations. He will say that a/b is unchanged by writing it

$a+e/b+e$, or he will take the square root of a product by operating on one factor only, or will add numerics of different denominations as 76 cm.+0.3mm.=76.3 cm."

From the chemistry department comes the statement that the students are unable to think quantitatively. When given the problem of type form: If sterling silver is 92 1-2 per cent silver and 7 1-2 per cent copper, how many pounds of sterling silver can be made of 100 pounds of silver? he is unable to handle it. The chemistry department says the student does not need high school mathematics but just good arithmetic. "Mathematics that will not function is of no more value than a knowledge of Chinese music." Dr. Morgan.

From the mathematics department comes the statement that the pupil is weak in the function concept. Mathematics to him is a dead thing instead of a means of relating, measuring or comparing movement or adjustment. Of course, the pupils are very rusty in fundamentals in many cases, but that is usually when it has been some time since they have had high school work. A carefully worked out course of correlated mathematics will give the mathematics in a way that it will function as the student learns it, thus making a *thinker* of the student instead of an *imitator*.

Another great weakness on the part of the student is his inability to express himself. He lacks a mathematical vocabulary, and is weak in mathematical language.

As to our third point, what preparation does a general course in mathematics give for a further study of mathematics, may I venture just a word before closing? The general course brings together the *simpler* principles of algebra, geometry, and trigonometry, with a direct application of the principles of numbering in such a way that the student makes the acquaintance of the three subjects and is thus encouraged to continue his work in mathematics. A correlated course will give to the student the practical values in such a form that he is led to appreciate the usefulness of quantitative thinking, and will help him to lay the foundation upon which he is the more able to build the complex principles of algebra, geometry, and trigonometry.

Professor G. W. Meyers, says that "Ideal teaching of high school mathematics consists in so implanting a definite quantum of mathematical knowledge and skill that the learner will in the learning acts, develop right study habits and skill in applying knowledge." "Good high school mathematics and good mathe-

matical teaching are chiefly beneficial to the public school pupil anywhere because, and in so far as, they beget and foster the habit of taking a rational attitude toward problematic situations, i. e., the habit of basing conclusions on the underlying facts." The general course if properly worked out and properly taught will lead to just such results.

I do not know how you who are directly connected with the subject of high school mathematics feel about the progress being made in this present stage of readjustment, but I felt as I was reviewing the literature in the preparation of my remarks that this is the brightest spot in the educational field. Thanks to the committee on Junior High School Mathematics! They have gone over the entire field, and have discarded much useless material, and have pointed out the need of stressing the essentials.

Surely if we will take up their suggestions and successfully carry them out we will turn out of high school a class of students able to think quantitatively concerning those things with which they come in contact in everyday life. That is mathematical education.

THE RÔLE OF MEMORY IN ALGEBRA

By Charles H. Butler,
University of Chicago.

(*Continued from page 613, October, 1922.*)

Chapter III—Memory Factors in Algebra.

Description of a Teaching Technique.

The development of a psychologically sound teaching technique is possible only in so far as the character of the psychological problem confronting the teacher is understood. Dr. Dewey says, "The problem (in thinking) is *the discovery of intervening terms which, when inserted between the remoter end and the given means, will harmonize the two.*" [1]He suggests that every case of rational thought involves five distinct steps:" (1) a felt difficulty, (2) its location and definition, (3) suggestion of a possible solution, (4) development by reasoning of the bearings of the suggestion, and (5) further observation and experiment leading to its acceptance or rejection; that is, the

[1]"*How We Think,*" p. 72.

conclusion of belief or disbelief." [2]In designing a technique of instruction it will be well to reckon with these suggestions. If a difficulty must be felt, how can it so be presented as to make the student realize that it exists without actually locating and specifying it for him? How can his effort towards its location and definition be motivated? How shall his interest be stimulated, and his efforts directed towards the discovery of possible solutions? How can he be led to gain facility in developing the implications of the suggestions, and carrying them to their logical conclusions? How can he be trained to test his inferences, and to decide as to the validity of the conclusions? A teaching plan should take cognizance of these questions, for they are vital to the success of the instruction.

A complete teaching technique, as outlined by Dr. Myers, comprises three distinct phases or motivating stages. First there is the *informal use stage*. The term *use* is to be distinguished from *application*. *Use* implies the employment of facts in an ordinary, unscientific way, without conscious realization of purpose or application of the idea as a means to a clearly defined end. It is a casual, "common-sense" recognition of the ways in which facts or processes function, without the recognition of any operating technique. In his treatment of *Generalized Experience*, Dr. Judd reiterates this idea: "On the other hand, the student may equally well be brought to the general principle through contact with a number of concrete cases. He now sees this case and now another. He learns to adjust himself in each of the particular cases without making at the outset any complete analysis of his experience."[3]

Such uses of ideas constitute a great part of our mental acts, and their importance can hardly be overestimated. Application, on the other hand, denotes the recognition of the operation as a step in an organic plan designed purposely to arrive at a particular type of solution, and of the fact that the operation itself involves a technique. The teacher must have constantly in mind the objective of the lesson, in order that he may direct the student's attention only to wisely considered and appropriate items and processes, for the purpose of this informal use stage is to enable the student to get a broad view and a clear grasp of the factors which will be of use in the consideration of the lesson. The lesson itself may be conducted as a review exercise, but it requires that the teacher plan carefully toward a clearly conceived end.

[2]*Psychology of High School Subjects*, p. 486.
[3]Ibid.

There are three steps in the informal use stage, and it is the teacher's function to see that through the operation of these three steps the student shall have his mind prepared for a well-organized attack of the new situation. The first of these may be called the *occasional use* step. The purpose here is to refresh the mind on processes and facts themselves, regardless of any application. For example, one must have the processes of multiplication and division in hand before taking up factoring. Hence many factorable forms should appear among the exercises in the teaching of these processes. In this way the idea may be habituated through incidental use. The previous incidental uses, discovered, perhaps, without the aid of the teacher, should be recalled and renewed by simple fact-and process-drills.

After this has been done, some time should be spent upon varied and incidental exercises in which the facts or processes just reviewed are involved. Several situations should be examined in order to discover the variety of ways in which these may be used. This may be called the *collated use* step (cf. Judd, op. cit. p. 43).

The third step in this stage is the *project* or *problem* step. Here the student is brought face to face with a problem involving the fact or process in a way exactly similar to that which will be met in the type of problem which is the objective of the study. These three steps form a sound psychological sequence, leading up naturally to a consideration of the type of situation which is embodied in the lesson to be studied, and preparing the mind of the student most effectively to grapple with this situation.

The next stage in the teaching technique is the *formal study* stage. If we may speak of the preparatory stage as a reconnoisance, and a marshalling of the forces in accordance with a preconceived plan, this second stage may be designated as the attack. It comprises four steps: (1) the conceptual step, the purpose of which is to clear up and organize the concepts of the solving process itself, (2) the concentration step, in which all energies are bent toward the recognition of a potential algoristic property of the process, and the acquisition of algoristic facility in handling the situation, (3) the assimilation step, the function of which has been fully described in a previous chapter, and (4) the testing step, in which the results obtained

are examined and checked up in detail. This furnishes the teacher with an opportunity of checking the student's work; it gives him a basis for grading, and enables him to discover the weaknesses of individual students. Moreover, it may be made a very reliable index to the efficiency of the instruction.

We might go further and speak of a graphic step, which would form a valuable supplement both to the conceptual step and the assimilation step. Its function would be to enhance, stabilize and rationalize, and thus to clarify and perhaps to objectify the understanding of the process of solution, and to aid in the assimilation of the idea.

A regrouping of these steps shows two distinct functions of the formal study stage. The conceptual and graphic steps constitute a rationalizing procedure, while the concentration, assimilation, graphic, and testing steps are more for the purpose of assimilation of the process, or of fixing it so firmly in the mind that its recognition and application in any situation will be easily effected, and of developing a degree of facility in the process *per se*.

The third stage in the teaching technique we shall call the *application stage*. Continuing our military metaphor, this consists in exploiting the field after taking it. The idea or process up to this time has been carefully isolated unto itself (i. e., presented very clearly in problems in which that procedure is essentially predominant). Now, however, the student is prepared to have it presented in connection with other ideas and processes. He has gained a mastery of it as a unit or single process; he must now learn to make selective judgments; to gain the ability to recognize it in any situation in which it may appear; to recognize its possibilities of application in different situations, and actually to apply it.

A good illustration of the meagerness of the ability of most high-school students in this direction is the difficulty which they have in applying their algebra to situations in physics. The trouble arises from the fact that they have not been taught how the algebra will function in such types of problems as they come in contact with here. Hence the necessity for this application stage (which is really a sort of follow-up stage) in teaching. Mathematics must be made to "carry over"; to function in situations other than the isolated ones in which it is originally learned. The student must gain, through such a variety of exercises as will be encountered in the application stage, a con-

ception of its irradiating power as it extends through many avenues, penetrating many fields of experience and finding application in a multitude of situations, and a facility in actually applying it in these different environments.

Memory and Teaching Technique.

Let us now consider the application of memory to the different stages and steps of this teaching technique. Examination of Table III revealed that seven types of memory were each definitely involved in one or more of the types of thinking which a study of algebra comprises. Table IV shows the high correlation between these types of memory and the different parts of the technique described above.

Table IV.

	Sheer Recall	Reflective Recall	Habitual Recall	Algoristic Recall	Comprehensive Recall	Conceptual Recall	Mnemonic Recall
Occasional Use Step			X	X		X	X
Collated Use Step		X	X	X		X	
Problem Step		X	X	X		X	
Conceptual Step	X	X	X	X		X	
Graphic Step	X	X		X		X	X
Concentration Step	X	X	X	X			X
Assimilation Step	X	X	X	X		X	
Testing Step	X	X	X	X		X	X
Application Stage	X	X	X	X		X	X

A glance shows that if we should eliminate the *comprehensive* type of memory, the correlation is almost perfect. Reference to Table I explains the fact that this type finds no correlation here, the only certain application of it being to the *research* and *appreciation* types of thought, neither of which is considered in the technique we have outlined.

The table requires no comment. It sets forth, more clearly and forcefully than mere words could, the sorts of memory processes which function in the various parts of the teaching scheme; and this constitutes a factor of sufficient importance to merit the consideration of the teacher in formulating his

plans and adapting his methods for teaching the lesson of the day. The planning of the lesson involves the consideration of the kinds of thinking which it will require, and if, in the anticipation of these, the teacher takes into account the types of memory that will function, he will be in a better position also to anticipate the situations in which the student will probably encounter difficulty, and those which will probably give him little trouble. The importance of this fact in connection with wisely planned instruction seems so self-evident that we shall not pause for further elaboration.

Supervisory Aspects.

The supervisory problem contemplates memory in a relatively less direct light than does a teaching technique. This is due to the fact that the supervisory problem is much the more comprehensive of the two. In addition to knowing the psychology of pedagogic methodology the supervisor must know how to maintain a healthy morale—a proper *esprit de corps*—among his faculty. He is the natural coordinator of the work of the department, and it is to him that the teachers will look for leadership and guidance. His chief duty is to know what the objectives of the instruction are and to get the teachers to work toward these. He must judge with reference to, and hold up as guiding ideals, practicality and social worth of content, and psychological validity of principle and method.

Requisite to the successful discharge of the obligation, and the fulfilment of the opportunity inherent in his directive capacity, is the possession of many qualities of leadership. He must have a *knowledge* of past educational practices and of current tendencies; of the attitudes and ideals of teachers; of the psychology (1) of the student's mind, (2) of the subject of instruction, and (3) of the teaching method. He must have *skill* in stimulating his teachers to the realization of ideals of increased and increasing efficiency, and in exhibiting to them organization of material and modes of presentation which contribute perceptibly to the attainment of the objectives. He must have *tact* in appraising outcomes of instruction, and in diagnosing and prescribing remedies for revealed defects in teaching.

This is not the place to enter upon the details of supervision. Our attention is drawn, however, to one point: namely, that the supervisor must be familiar with the psychology of instruc-

tion, of the student, and of the subject matter. This is an indispensable factor in the consummation of his chief function. The student is not a fixed, passive individual with an unchanging *set* of mind. His intellectual power is constantly expanding with experience, and his mental processes bring about a thousand constantly shifting situations and attitudes. Moreover, different phases of the subject of instruction involve appeals to different phases of the student's intellectual activity.

The psychology of instruction comprehends the psychology both of the student and of the subject. Wisely to guide in the instructive process, then, the supervisor must be on perfectly familiar terms with these psychological problems. Particularly he must know, with reference to the various parts of the subject the sorts of activity which will be demanded. Of these many might be mentioned: for example, the rôle of object work; the rôle of volition in thinking; the rôle of abstraction; etc., etc. Among others, he should know the rôle which *memory* plays in the mastery of the different parts of the subject. For memory, as well as volition or abstraction, is a psychological function, and the proposition of its fundamental application in the majority of the thought processes involved in algebra (although through the fact of unfortunate and ambiguous terminology it has sometimes come to be the subject of bitter debate among writers) will in the last analysis bear all the scrutiny which can be applied to it, and will in the end emerge, a more soundly established doctrine than ever before.

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A SUCCESSFUL APPARATUS FOR DEMONSTRATING OSMOSIS.

By S. G. Rich,

Concord State Normal, Athens, West Virginia.

The difficulties in the way of demonstrating to classes the effect of osmotic pressure in producing a passage of water from a dilute solution or pure water into a denser solution are well known. During the past few months I have succeeded in arranging an apparatus, a slight variation on that usually and more or less unsatisfactorily used, that gives a very clear demonstration of this action.

Instead of using an animal membrane, which is usually too elastic to give easily visible results, or a parchment-membrane, which is most often subject to trouble from minute pinholes, I used a membrane of ferric silicate supported on parchment paper. The making of this membrane is the chief feature of my apparatus.

In the funnel of a thistle tube I placed about 2 cc. of solid ferric chloride. I then tied over the funnel a piece of wetted parchment-paper. I inverted this apparatus in a mixture of equal parts of commercial water-glass and water, setting it so that only the flat surface was in contact with the water-glass, and not over one-eighth inch below the surface. I kept the apparatus in this position for about twenty-four hours. I then carefully filled the thistle, through the tube, with water, and set it so that it was immersed about an inch deep. After keeping it in this position for another day, I was gratified to find that the precipitate of ferric silicate had completely and strongly sealed the membrane to the bulb.

This apparatus, with the yellow-brown solution of ferric chloride within, showed the rise of water due to osmotic action both quickly and clearly, when set in a beaker of water and adjusted so that inside and outside levels were the same at the start. I have used it repeatedly, and with success each time. The rise in the tube of the thistle-tube has been as rapid in some instances as a quarter of an inch in the first eight minutes and has continued undiminished for two hours. I have not had it in operation for more than this stretch of time at one continuous session.

A great advantage of this apparatus has been the ease with which any accident to the membrane may be repaired. On one occasion a student, handling the apparatus unskilfully,

caused a slight break in the sealing of the membrane. An immersion of fifteen minutes in fifty-per-cent water glass sealed it as tightly as ever.

The apparatus is preserved in a tall jar, with the thistle and membrane immersed in a ferric chloride solution approximately isotonic with that within the thistle. It has remained in good condition and ready for use at any moment, in this solution.

As compared with other membranes, this one has the advantage of being sufficiently rigid so that there is no loss of apparent rise in the fluid within due to stretching by hydrostatic pressure of the solution within. It also is sufficiently speedy in action to make a forceful demonstration.

NEW MAP OF VIRGINIA

Shows Power Stations and Transmission Lines of Public Service Companies

A new map of Virginia on a scale of 1:500,000, showing the location of the power stations and transmission lines used in public service and the names of the public-utility companies has just been published by the United States Geological Survey, Department of the Interior.

This map is one of the series of State power maps now being published by the Geological Survey. Maps have already been completed of New York, Pennsylvania, Massachusetts, Rhode Island, Connecticut, Maryland, Delaware, District of Columbia, Vermont, New Hampshire, and New Jersey, and maps of Indiana, Maine, and West Virginia are being prepared for publication. The maps that are available for distribution may be purchased from the Director of the United States Geological Survey for 50 cents a copy.

These maps will be valuable to those who are interested in the interconnection of power plants, to those who wish to establish manufacturing plants within reach of electrical power, to municipalities contemplating the use of electricity for light and power, and to municipalities considering the feasibility of purchasing electricity instead of reconstructing an old or obsolete municipal plant. The Geological Survey recently made a special investigation of the possible economy of fuel, labor, anmd aterials resulting from the use in the Boston-Washington industrial region of a comprehensive system for the generation and distribution of electricity to transportation lines and industries. The report of this investigation was published as Professional Paper 123. *A Superpower System for the Region between Boston and Washington.* This investigation showed conclusively that plants of 500-horsepower or less can economically purchase energy instead of generating it, as it was found that small plants consumed from 6.23 pounds of coal per kilowatt-hour, while the large plants consumed but 2.14 pounds per kilowatt-hour. The variation in the cost of maintenance, labor, and supplies was even more marked, the ratio being about 4:1 against the small plants.

THE MAGNETIC-MECHANICAL ANALYSIS OF FERROMAGNETIC SUBSTANCES, ITS BEARING ON THEORIES OF MAGNETIZATION[1]

By S. R. Williams,
Oberlin College, Oberlin, Ohio.

Synopsis.

Magnetic-Mechanical Analysis.—An attempt to interpret the mechanical properties of a substance from its magnetic characteristics must be preceded by a correlation of the mechanical and magnetic properties of definite ferromagnetic substances. Not only does such a study have great practical significance but it must also lead to clearer concepts of the mechanism of magnetization. What happens to a bar of iron when it is magnetized? Magnetostriction must throw light on this problem, because one effect observed is a change in dimensions. This is a very definite mechanical effect and ought to be interpretable.

Joule and Villari Magnetostrictive Effects.—This paper is a correlation of the Joule and Villari effects in rods of steel, nickel and alloys of nickel. Eventually such data will be of value in judging the mechanical properties of these substances from their magnetic behavior. A definite result has been attained in showing that there is no Villari reversal effect present in nickel when *all* extraneous fields have been removed. This paper attempts to picture what happens in the process of magnetization and also discusses a very useful method of magnetic testing.

Introduction.

Matteuci[2] seems to have been the first to note that, when a magnetized iron bar was pulled lengthwise, there was an increase of magnetism. Villari[3] went a step farther and found that using magnetic fields greater than those of Matteuci, a longitudinal pull decreased the magnetism in the magnetized iron rod. This reversal of the effect of a pull on a magnetized bar is now known as the Villari reversal. If one plots the relation between the intensity of magnetization and the magnetizing force when no longitudinal pull is applied and again when the rod is under a tension, there will be a point where the two curves intersect, which is known as the Villari critical point. It is that field strength at which a pull does not affect the intensity of magnetization.

[1]Experimental Portion of this paper presented before The Ohio Academy of Science, Nov. 28, 1913.
[2]Matteuci, Comp. Rend., p. 301, 24, 1847; Ann. de Chim. et d. Phys., p. 416, Vol. 53, 1858.
[3]Villari, Pogg. Ann., p. 87, Vol. 126, 1865.

In the case of a magnetized nickel rod there seems to be no question but that a longitudinal stress applied to the rod changes the magnetic induction through it, but if one may judge by the literature, however, the presence of a Villari reversal point does not appear to be so definite. Ewings book, "Magnetic Induction in Iron and Other Metals," whose third edition appeared in 1900, contains the statement (page 199) that, "there is nothing in nickel that corresponds to the Villari reversal in iron," and yet six years before that Heydweiler[4] had published results showing, by magnetometric methods, the presence of such a reversal at smaller field strengths than for iron. In 1904, Honda and Shimizu[5] cast doubt on Heydweiler's results because they were not able to find the reversal in specimens which they used. Heydweiler[6] pointed out in his reply that positive results carried more weight than negative ones. He also pointed out that Meyer[7] had found a Villari reversal in nickel. The difficulty of coordinating these results lies in the fact that it is impossible to find two specimens of nickel possessing the same magnetic properties. Even two samples cut from the same rod will show variations, hence two specimens obtained from entirely different sources may easily have a large difference in magnetic quality as may be inferred from the varied results just cited. In the discussion which has arisen it is unfortunate that cooperative research could not have been undertaken in which the investigators on both sides of the question might have tested the same specimens. Inasmuch as this was impossible, crucial experiments must be devised to determine the absence or presence of the Villari reversal, which will apply in general. This has been accomplished by showing that the introduction of an extraneous factor produced the Villari reversal and by its removal this effect was lacking.

Thomson[8] has pointed out that it is possible, from theoretical considerations, to predict the general character of the effects of stress from a knowledge of the changes in dimensions caused by magnetization. Consequently a double check may be obtained for indicating the presence or absence of the Villari reversal by studying both the changes in length due to a magnetic field (Joule effect), and the effects of stress on magnetization (Villari effect), the studies being carried out on the same

[4]Heydweiler, Wied. Ann., p. 462, Vol. 52, 1894.
[5]Honda and Shimizu, Phys. Zeitschr., p. 254, Vol. 5, 1904.
[6]Heydweiler, Phys. Zeitschr., p. 255, Vol. 5, 1904.
[7]Meyer, Wied. Ann., p. 134, Vol. 59, 1896.
[8]Thomson Application of Math. to Phys. and Chem., p. 47 et seq.

specimens of nickel or other ferromagnetic substance. If in a bar of nickel we could find a change in length similar to that found in iron then we might expect to discover a Villari reversal also.

In a former paper[9] it was shown that in two different specimens of nickel rods, Nos. 5 and 6, there was present under certain conditions a reversal of the Joule effect as the imposed magnetic field was varied from zero upwards. The condition for this effect was the presence of an extraneous magnetic field.

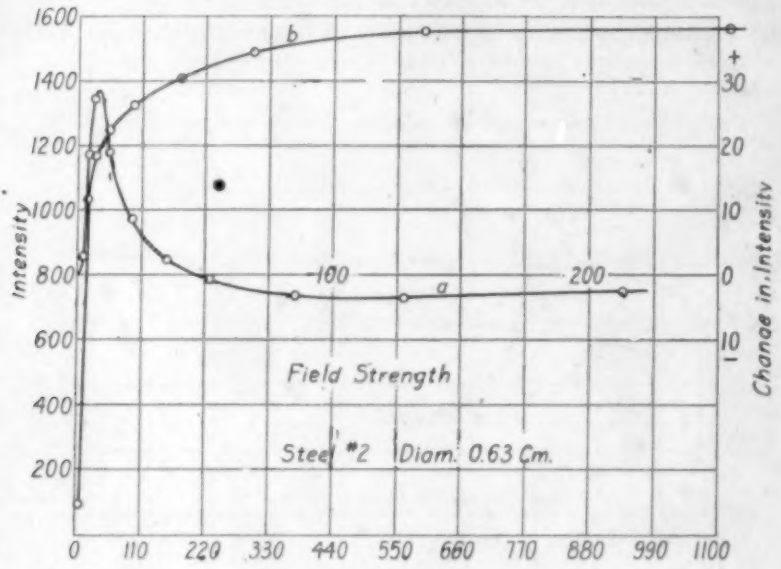


FIGURE 1.

From the interrelation of magnetic and mechanical properties of ferromagnetic substances, enunciated by Thomson, it might be expected that under the same conditions these same rods would show a Villari reversal. The chief aim of this paper is to investigate this point. Not only does this study deal with a comparison of the Joule reversal with the Villari reversal effect in the two specimens of nickel but it has been extended to steel and nickel alloy rods in which the change in length is either an increase or a decrease for all field strengths. The experimental results are in accord with Thomson's view about

[9] Phys. Rev., N. S., 10, p. 129, 1917.

predicting the results for the Villari effect, if we know the Joule effect. Not only is there a Villari reversal in those specimens in which there is a reversal of the Joule effect, Fig. 1, but for those specimens which show no reversal of the Joule effect there is no Villari reversal, Fig. 2. In a manganese-nickel alloy, Fig. 3, in which there was a shortening for all field strengths a pull decreased the magnetism for all field strengths, while in the case of a nickel-steel rod, Fig. 4, whose change in length was an increase for all field strengths, the effect of a pull was to increase the magnetism in the magnetized rod.

In studying the Villari effect it has been customary to plot the relations between the intensity of magnetization and field

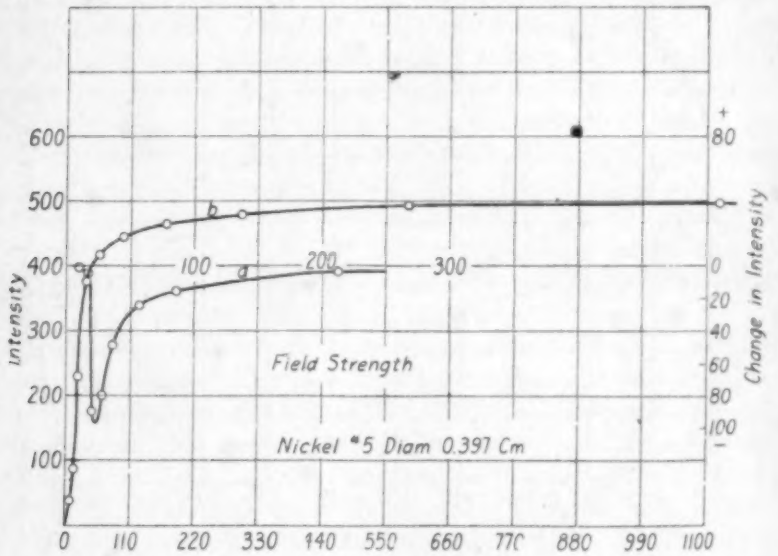


FIGURE 2.

strength, both for the stressed and the unstressed condition, an intersection of the two curves indicating a Villari reversal. If instead of plotting the values of I for the stretched rod, the differences in the values of I for the two conditions be plotted with respect to H, a curve is obtained, which emphasizes the presence or absence of the Villari reversal better than the usual way, for, if a reversal does occur, the difference curve will cross the zero or base line and the point of crossing indicates the critical field strength at which the Villari reversal occurs. In the graphs given, therefore, two curves will be plotted for each specimen; (b) values of I for varying values of H when the rod

is unstretched and (a) the difference values of I for the stretched and unstretched conditions. The way in which the Villari reversal is associated with a Joule reversal is shown in Fig. 5 where a couple of characteristic sets of curves are plotted, one for steel and the other for nickel. If there is a Joule reversal, as in the case of steel, (a) then the curve crosses the zero axis (ca. 300 gauss) and correspondingly the curve for the Villari reversal, (b) does also, but at lower field strengths. (ca. 40 gauss.) If, as in the case of nickel, no Joule reversal occurs, (c) there is no cutting of the zero axis and correspondingly there is no cutting of the zero axis by the curve for the Villari effect, (d). If similar curves be plotted for cobalt, effects just the

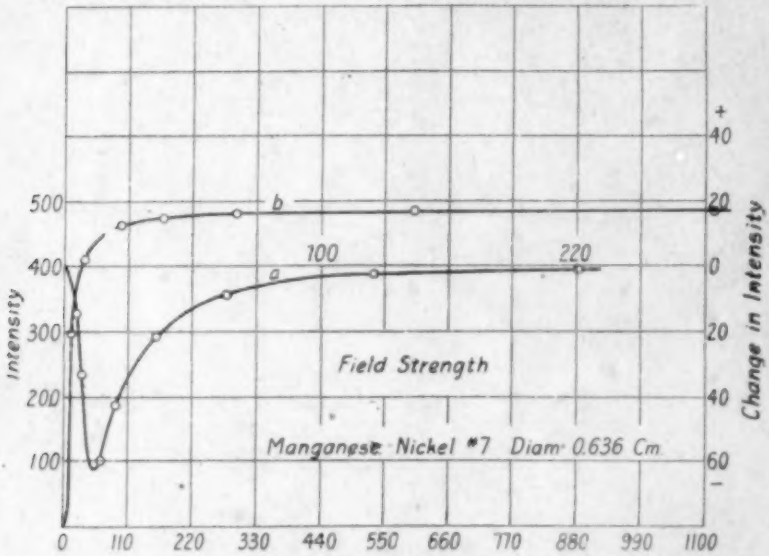


FIGURE 3.

reverse of those for steel will be found while some of the manganese alloys give the reverse of those for nickel.[10]

EXPERIMENTAL.

It was found that if the earth's field was not annulled there was present a Villari reversal when the magnetizing field, H, was opposed to the vertical component of the earth's field. Fig. 2 shows that the Villari reversal due to the earth's field could be eliminated by an extraneous field just equal and oppositely directed to the vertical component of the earth's field. It is to be remembered that the magnetizing coil and the rods were used in a vertical position. As a further corroboration of the artificiality of the Villari effect found in nickel, a vertical

[10]Phys. Rev., 34, p. 44, 1912.

extraneous field opposed to the earth's component was applied to the nickel rod, No. 5; this left a vertical component of about one gauss directed upward. If the magnetizing field was applied to the nickel rod in this extraneous field, a Villari reversal was found, as shown in (a) Fig. 6, when the main field H was directed downward, i. e., oppositely to the extraneous field. When the main field was directed upwards in the same direction as the extraneous field, no apparent Villari reversal occurred. This also was true for the vertical component of the earth's field as an extraneous field, that a Villari reversal occurred only when the main magnetizing field was opposed to the vertical component of the earth's field. Before each set of readings

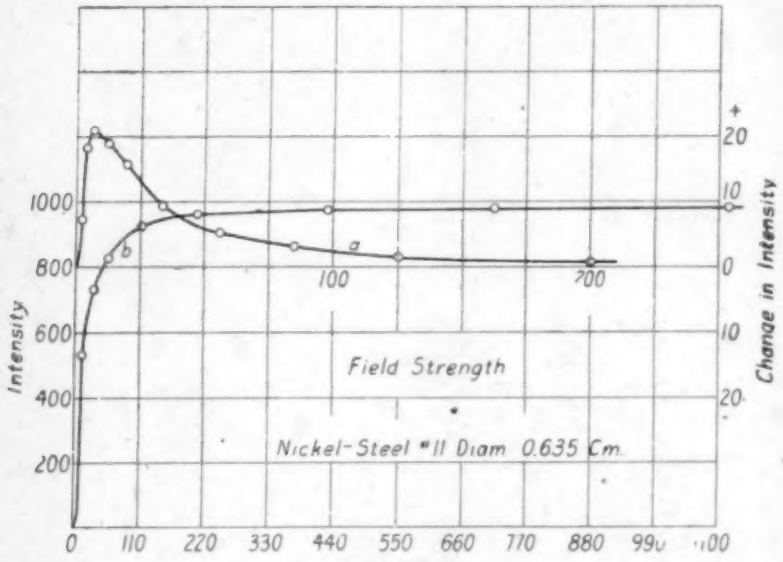
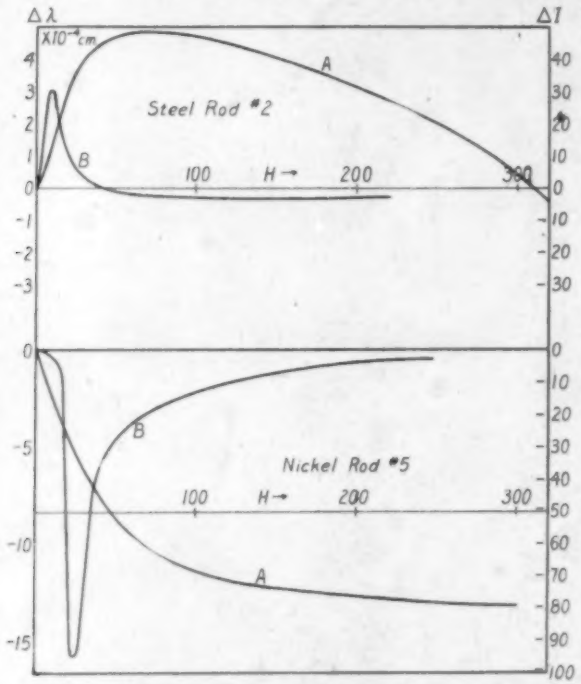


FIGURE 4.

was taken, the rod was demagnetized by decreasing an alternating current magnetic field applied to the rod in which the initial maximum field strength was equal to the maximum steady field applied previously to the rod. In the case of steel this seemed to effect complete demagnetization but for nickel, if the slightest trace of an extraneous field existed, the rod would show after a process of demagnetization a permanent magnetization in the direction of the extraneous field. As mentioned elsewhere[11] this was a hair-trigger effect and the absence or presence of the permanent magnetization in the nickel rod, after the process of demagnetization had been

[11] American Jour. of Sci., 36, p. 560, 1913.

carried out, was a very sensitive test as to whether the vertical component of the earth's field had been compensated or not. Thus not only has it been shown that nickel does not possess a Villari reversal under normal conditions but the means have been shown for artificially producing it. For the theory of the process of magnetization it is very important to notice that the reversals in nickel occur only when the magnetizing field and the extraneous field oppose each other. On the other hand it is significant that iron and cobalt possess these reversals naturally.



CONJECTURES AS TO THE MECHANISM OF MAGNETIZATION.

One frequently tries to picture the process which goes on in a ferromagnetic rod when subjected to a magnetic field. In a number of papers[12] it has been pointed out that it was a great help to think of the elementary magnet as a positive oblate spheroid about which negative electrons were revolving. It is particularly helpful for the phenomena being discussed in this paper. For instance, if the elementary magnet is a small planet with its attendant satellites, what will be the effect of applying a tension to an aggregation of such oblate spheroids as they are supposed to be? In hopes that it might throw some

[12]Phys. Rev., 34, p. 40, 1912; 35, p. 282, 1912; N. S. 2, p. 241, 1913; 10, p. 129, 1914.

light on the subject the following experiment was performed: a circular opening, two centimeters in diameter, was cut in a piece of dentist's dam, 10x13 centimeters in size. In this opening a wooden oblate spheroid was inserted as shown in (a), Fig. 7. Two opposite edges of the rubber sheet were fastened to two wooden blocks so that as the blocks were separated the rubber was uniformly stretched in the direction of the tension. When the rubber membrane was stretched in a direction of about 45 degrees, with the major axis of the spheroid, the latter would swing around gradually so that its major axis was parallel to the direction of stretch of the rubber. (b),

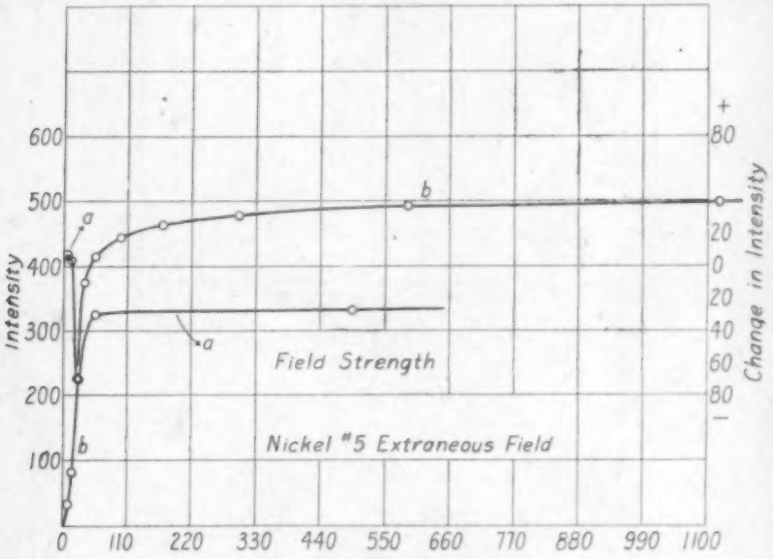


FIGURE 6.

Fig. 7, shows the tension being applied while (c) shows the complete turning of the spheroids to the position where the major axis is parallel to the direction of stress. (b) shows very clearly the couple which is brought into play tending to produce rotation of the spheroids. The arrows indicate the direction of pull in (b) and (c), Fig. 7. The major and minor axes of the spheroid were 3.7 and 1.6 cms. respectively.

This experiment has an application in the proposed magnetic theory. In the virgin state a bar of iron or steel has, according to Ewing, its elementary magnets turned in all possible azimuths, but the majority will be turned so that the major axes make an angle (less than 90 degrees) with the axis of the rod. A pull will therefore tend to set the main body of the spheroidal

magnets with major axes parallel to the direction of pull. For a weak magnetic field which does not exert a large directive force on the elementary magnets, this may easily be accomplished, but in turning the spheroids with major axes more nearly parallel to the direction of pull and of the magnetic field

FIGURE 7.

there is given greater inductive power to the rod because, as has been shown,[13] a group of iron spheroids shows greater intensity of magnetization when the major axes are parallel to the field than when normal. This is exactly what is observed in the Villari effect for steel; a pull in a weak magnetic field increases the magnetization.

[13] Phys. Rev., 35, p. 282, 1912.

If instead of one spheroid in (c), Fig. 7, there had been a large group, a further pull would only have tended to separate them. So when a strong magnetic field is applied to a rod, the spheroidal magnets under the influence of the magnetic field have been turned with major axes normal to axis of rod and the field and are held in the grip of the applied magnetic force. Any pull applied to such a system of spheroids simply tends to separate them and so decreases the magnetization.[14] This is what is observed in the Villari effect for steel.

The question must at once arise, how does this apply to substances whose Villari effect is just the opposite of that in steel as in the case of cobalt or a wholly different type as nickel? The answer must depend on the initial orientation of the elementary magnets and this depends again, as has been shown,[15] on the balance which exists between the magnetic moment of the revolving electrons and the magnetic moment due to an apparent induction in the nucleus of the elementary magnets. The model of the elementary magnet, just cited,[15] performed evolutions which would produce the four distinct types of changes of length which we get in the Joule effect. Its movements were produced by the action of the two moments present in the elementary magnet, viz., that due to the nucleus and the other due to the revolving electrons. This means to say that it appears as though a part of the magnetic properties of ferromagnetic substances lies in the nucleus of the atom.

To quote from a recent paper[16] "there must be given to the positive nucleus of the atom a property of induction just as Ewing had in his elementary magnets and, for ferromagnetic substances at least, these nuclei ought to have different dimensions in different directions, capable of being rotated by means of an external field" if we would explain many of these magnetostrictive effects.

The foregoing picture of the elementary magnets explains the fictitious Villari effect observed in nickel when the magnetizing force is opposed to the extraneous field. The extraneous field is already applied to the rod and as a result the elementary magnets appear to be set with major axes normal to that field. When the main field is applied in the opposite direction, the elementary magnets will swing through 180 degrees as the main current in the solenoid is increased from zero upward. During this process the rod will lengthen and then shorten as has been

[14] Phys. Rev., 35, p. 285, 1912.
[15] Phys. Rev., 34, p. 43-44, 1912.
[16] Science, N. S. 54, p. 339, 1921.

observed,[17] concomitant, the Villari effect described in the preceding pages. It is to be expected that this will occur at low field strengths and this is just what is observed.

MEASURING MAGNETIC INTENSITIES.

In measuring the intensity of magnetization in these rods a method was used which is not commonly given in laboratory methods and which for small values of I is particularly applicable. Ordinarily an exploring coil is wound about the rod and connected to a ballistic galvanometer. When the rod and the exploring coil are placed in a solenoid with uniform field and the field is suddenly reversed there results a transient current in the exploring coil which is a function of the total magnetic flux through the rod. The charge, Q, flowing through the galvanometer is:

$$Q = \frac{2\pi r_1^2 H n_1 + 4\pi I(\pi r_2^2) n_1}{R} \qquad (1)$$

where r_1 and r_2 are the radii of the exploring coil and the rod respectively, H the field of the solenoid, n_1 the number of turns in the exploring coil, I the intensity of magnetization and R the resistance of the galvanometer circuit.

If the permeability of the rod is small the second term in (1) becomes very small with respect to the first and small variations in I are not readily detected. In order to use this method effectively the induction due to the first term must in some way be annulled, leaving only that due to the second. Lord Rayleigh[18] in examining the permeability of iron in very weak fields used a magnetometer method, in which the magnetizing effect of the solenoid was compensated by another coil leaving only the magnetizing effect of the specimen to act upon the magnetometer. Inasmuch as a magnetometer may always be replaced by an exploring coil and a ballistic galvanometer, Rayleigh's method suggests the use of an exploring coil and a ballistic galvanometer in such a way that the first term in equation (1) may be eliminated and we can study the effects due to the specimen itself.

In the method employed in this work, the exploring coil is made up of two coils connected in series in such a way that the current set up in them are in opposite directions. The

[17] Phys. Rev., N. S. 10, p. 132, 1917.
[18] Rayleigh, Phil. Mag., 23, p. 225, 1887.

outer coil has a radius about twice that of the inner and only about half as many turns, n_2, if this double coil without a ferromagnetic core is now placed in a solenoid of uniform field and the current suddenly reversed the number of turns in the two exploring coils may be so adjusted that no deflection of the galvanometer occurs. Here

$$Q = 2\frac{\pi r_1^2 H n_1 - \pi r_2^2 H n_2}{R} = 0 \qquad (2)$$

If now the specimen to be tested, radius r_3, is introduced symmetrically into the balanced coils and the field in the solenoid suddenly reversed, a deflection of the galvanometer will occur for the reason that

$$Q = 2\frac{(\pi r_1^2 H n_1 + 4\pi I n_1 \pi r_3^2) - (\pi r_2^2 H n_2 + 4\pi I n_2 r_3^2)}{R} \qquad (3)$$

$$= \frac{8\pi^2 r_3^2 (n_1 - n_2) I}{R}$$

i. e., $Q = kI$ or deflection of galvanometer $\propto I$. k may be determined by means of a *long* slim solenoid, radius r_4, which will pass through the double exploring coil, all the flux in the slim solenoid, $\pi r_4 (4\pi n_4 i)$, passes through the double exploring coil, so that a reversal of the current in the slim solenoid sends a quantity of electricity, Q^1, through the galvanometer such that

$$Q^1 = \frac{8\pi^2 r_4^2 n_4 (n_1 - n_2) i}{R} \qquad (4)$$

The exploring coil and galvanometer have a fixed resistance, R, so that the deflections, θ_1 and θ_2 of the galvanometer for (3) and for (4) will be directly proportional to the charges and we may write:

$$Q : Q^1 = \theta_1 : \theta_2 = \frac{8\pi^2 r_3^2 (n_1 - n_2) I}{R} : \frac{8\pi^2 r_4^2 n_4 (n_1 - n_2) i}{R} \qquad (5)$$

or the intensity of magnetization,

$$I = \frac{\theta_1 r_4^2 n_4 i}{\theta_2 r_3^2} \qquad (6)$$

This means to say that the intensity of magnetization is determined directly in terms of the deflections of the galvano-

meter, the radii of the rod and the slim solenoid, the number of turns on the slim solenoid and the current flowing in it. By this method the data just given were obtained.

After obtaining the values for the intensity of magnetization for the various rods shown in Figs. 1, 2, 3, etc., deflections of the galvanometer were taken when the rods were normal and when stretched by a mass of 22 Kg. From the ratio of the two deflections and the values of I as determined above, the per cent and actual change in I were determined. The average of six reversals was taken in determining each value of I given in the graphs, while for the variation of I with tension sixteen observations were taken, for each field strength, eight with load and eight without load. It would not seem impossible to apply the principle, used in this study, to commercial permeameters and make their range somewhat greater.

The question as to the presence of a Villari reversal in nickel seems to be definitely answered. Both from a study of the Joule effect and the Villari effect it has been shown that when extraneous fields have been removed or compensated, no reversal effect exists in nickel. Nickel is hypersensitive to extraneous fields such as earth's field, field of ammeters, etc. Honda and Shimizu contended in their work that Heydweiler had not eliminated the effect of the earth's magnetic field. Heydweiler replied that he had. This work would indicate that he had some extraneous field present, if not the earth's field.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS ANNOUNCEMENT OF FALL MEETNIGS.

The Seventy-Eighth Meeting, Rhode Island State College, Kingston, Rhode Island.

A trip into the beautiful Southern Rhode Island region was enjoyed by the Association on the occasion of the seventy-eighth at the Rhode Island State College, Kingston Rhode Island. Many made the trip by automobile from Providence, Boston, Springfield and other points.

The program included an address by Dr. Saul Dushman of the General Electric Company on "Atomic Structure of Matter."

This address was illustrated by moving picture films and models of the arrangement of electrons in the atoms of the various elements. Mr. Krank W. Keaney of the chemistry department of the State College, Kingston, gave a demonstration of lecture table experiments in chemistry and Dr. Burt Hartwell, Director of the Experiment Station of Rhode Island conducted the party about the experimental plots of the station. On these plots much notable research work in agricultural science has been done in the last quarter century.

THE SEVENTY-NINTH MEETING, HARVARD UNIVERSITY.

The seventy-ninth meeting of the Association will be held at Boyleston Hall, Harvard University, Cambridge, Massachusetts on Saturday, November 18, 1922. The meeting will begin at 10:00 a. m.

In the forenoon two addresses will be given, one by Dr. James Bryant Conant, Assistant Professor of Organic Chemistry at Harvard University on "Organic Chemistry in Everyday Life" and the other by Dr. Norris F. Hall of Harvard University on "Isotopes."

The Association will lunch at the Georgian Cafeteria, Dunster Street, Cambridge, near Harvard Square.

After lunch the annual business meeting of the Association will be held, at which reports of officers for 1921-1922 and reports of the work committees of the Central Division will be given.

At the business meeting, officers for the year 1922-1923 will be elected. It is expected that there will be a large attendance of members from all parts of New England at this meeting.

THE EIGHTIETH MEETING, HARTFORD PUBLIC HIGH SCHOOL.

The eightieth meeting of the Association will be held on Saturday, December 9, 1922, at the Public High School, Hartford, Connecticut.

This is the fourth regional meeting of the Western Division of the Association, which includes Connecticut and Western Massachusetts. This division now has a membership of nearly 100 and holds two meetings a year.

The program of the Hartford meeting will include a radio concert, a talk by Mr. Edmund Goodreau of the Ansonia High School on "The Chemistry Teachers' Problem in the State of Connecticut," and a talk on an up-to-date chemical subject by Dr. J. Albert Hill of Wesleyan University.

A part of this meeting will be taken over by the members of the Radio Relay League, which has its headquarters in Hartford.

It is also planned to visit the broadcasting station of the Hartford Courant at their invitation.

Reports of the work committees of the Western Division will be given and plans for the further extension of Association work made.

Members from Connecticut and Western Massachusetts should support this meeting by their attendance, and it is expected that they will bring to the meeting science teachers or others who may be interested.

The program at the high school will begin at 10:00 a. m.

NEW ENGLAND ASSOCIATION OF COLLEGES AND SECONDARY SCHOOLS JOINT MEETING SCIENCE SECTION.

On December 9, in Boston, the Association, in cooperation with the Eastern Association of Physics Teachers and the General Science Club, functions as the Science Section of the New England Association of Colleges and Secondary Schools.

The program is as follows: Mr. Hermann C. Lythgoe, Director of the Department of Public Health of Massachusetts will give an address on "The Vitamine Bunk," and Dr. Herbert Clark of the Technical Department of the Taylor Instrument Company, Rochester, New York, will give an illustrated lecture on "Temperature Measuring Instruments in the Making."—S. Walter Hoyt, Secretary, 20 Stone Road, Belmont, Mass

OIL FIELDS COME BACK

Fields Abandoned too Soon Must Be Redrilled

Some oil fields whose dwindling output seems to show that they must soon be abandoned may yield more oil in the future than in the past, and others that seem dead are likely to be resurrected, according to K. C. Heald, of the United States Geological Survey, Department of the Interior, who finds abundant evidence to support these statements in recent discoveries and developments, as well as in work done by the Survey.

Resuscitation of the Tidioute Field

Only a short time ago most oil operators looked upon the old Tidioute field, in Warren County, Pa., as a field with little present and less future importance. Such wells as were being pumped yielded insignificant amounts of oil, and the general opinion was that the field had been so thoroughly drilled that further exploration would be futile. One man, however, refusing to share the general opinion, clung obstinately to the idea that the early drilling had not conclusively proved that the deep sands below the beds from which the wells were producing were barren of oil. Awaiting his opportunity he drilled a deep well, disregarding both skepticism and ridicule, and on August 5, 1922, when his drill bit into the Queen sand, 770 feet below the sand which had up to that time yielded most of the oil in the district, he obtained a flow of oil that silenced his critics and restored to importance one of the oldest producing fields in Pennsylvania. This new well in an old field yielded 500 barrels a day and was not only the best well drilled in the district, but one of the most productive wells drilled in recent years in the state.

Gusher in the Old Unity Field

This successful well in the Tidioute field was still fresh in the minds of the operators in Pennsylvania when another old field in the state "came back" with an even larger producer. This well, in the Unity field, Allegheny County, which gushed at the rate of more than 1,400 barrels a day and took the title of "the biggest well of the year in Pennsylvania," again proved that drilling in old fields is likely to pay if it is intelligently directed.

Many New Productive Wells in Old Fields

Productive wells in old fields are not so uncommon as the publicity given the examples cited above might seem to indicate. In many a field two or more "booms" have followed the discovery either of new oil-bearing beds below the ones first developed or of an extension of the field in some direction where the dry holes that bordered the area that was originally productive were due to some local cementation or to a lack of porosity or some other condition in the oil sand and did not mark the true edge of the pool. The surprisng thing is not that these discoveries are made but that they have led to so little drilling in search of new sands and of extensions of pools in fields where production started many years ago and that geologists so generally devote their time to a hunt for new producing areas and neglect so much the work that would lead to the complete development of the older fields.

Successful New Wells in Western Fields

New discoveries in old fields are by no means limited to the Appalachian oil fields. In the mid-Continent fields more than one pool that was apparently nearing extinction has been brought back to its original productivity by some operator who refused to join in the belief that it had been exhausted, or by some newcomer who did not share the pessi-

mism regarding the future of the pool that the failure of test wells had brought to the older operators. A striking example is the Electra pool of northern Texas, which during the last year has gained a place among the more productive fields of Texas after years of insignificant production. Pools in eastern Oklahoma have been rejuvenated as one deep sand after another has been discovered. The old fields of eastern Kansas have been repeadedly extended during the last few years, lagrely through the efforts of optimistic geologists and operators whose study of the region had convinced them that it had not been thoroughly explored.

Help of the Geologist is Essential

A good rule for those who look for new productive areas in old fields is that the older the field the better the chance that some oil has been overlooked. Twenty years ago operators were not so skillful as they are today, and they were also much quicker to believe that a pool had been completely drilled up or an area condemned than they are today. Also, and perhaps most important of all, they did not then have the advantage of the intensive application of geology to the discovery and development of oil that has contributed so much to the discovery of new pools, particularly in the mid-Continent, Rocky Mountain, and California fields, during the past five years. It may be confidently predicted that as new pools become scarcer and harder and more expensive to find, oil operators will call upon geologists more and more to study intensively the old pools, either those that have been abandoned or those that produce only small quantities of oil, and that the studies will result in the discovery of oil in territory that is now looked upon by most oil men as almost worthless.

Geologic Evidence is First Requisite of Success

A belief that many old oil fields are underdeveloped does not mean that random drilling in them is justifiable, any more than random drilling without geologic advice in wildcat areas is justifiable. The man who makes a drilling location merely because it is near old producing wells and depends on his luck to guide him to the right spot to discover an extension of the field, or one who drills in an old pool to find a new and deeper sand merely because of a "hunch" he may have that it is there has all the odds against him, and his chances for success are slight. Such operations are as senseless and ill-considered as it would be to purchase a second-hand automobile without knowing anything about its appearance, condition, or the distance it had run. There is little more common sense than there is in laying a pipe line to a drilling well before it is known whether or not the well will find oil. Haphazard drilling in old fields is particularly foolish and unjustifiable, for evidence is almost always available to tell whether or not there is a chance for new production, and facts can almost always be found to show where drilling would be most advisable.

Logs of Deep Wells Are Valuable

In most districts where oil has been produced for a number of years a few scattered wells have been drilled deep. The records of these wells, combined with a study of the regional geology, and particularly of the geologic history, will tell whether or not there are formations below the producing beds which may be a source of oil and whether they include sands or other porous beds. Study of the geologic structure with the aid of well records will show the location of anticlines that may have formed traps for oil in the deep-lying beds.

Use of Diamond Drill Will Help Exploration

The diamond drill, which is being used more and more in the search

for oil, should be particularly helpful in extending old pools, for the core that it yields will reveal the exact character of the beds it penetrates. If the sand in a dry edge well is "tight," containing lime or other cementing material, it is reasonable to hope that the dry well no more indicates the edge of the pool than a knot hole indicates where the edge of a plank may be, so that drilling beyond it, outside the supposed limits of the pool, is justifiable.

A RESIGNATION.

Dr. Benjamin C. Gruenberg has resigned from the United States Public Health Service, Washington, where he has for the past two years worked on the Government's program of sex education in high schools and colleges, to study the problems of the educational use of motion pictures with the Urban Institute, Irvington-on-Hudson, New York. Dr. Greunberg has been continuously engaged in educational work in New York since 1902.

ANNOUNCEMENT.

The Weston Electrical Instrument Co. of Newark, N. J., announces that Mr. G. P. Atkinson for several years connected with its Home Office Sales Organization has opened an office in Atlanta, Georgia, for the territories of Georgia, South Carolina and Northern Alabama. In addition to Weston Instruments, Mr. Atkinson has several other Nationally recognized lines of electrical equipment.

PROGRAM FOR SECOND ANNUAL MEETING OF SCIENCE SECTION OF ASSOCIATION OF COLLEGES AND PREPARATORY SCHOOLS OF MIDDLE STATES AND MARYLAND.

To Be Held at Tower Hill School, Wilmington, Delaware, Saturday, December 2, 1922, 9:45 a. m.

Business Meeting: Election of officers.

Address, "Science Teaching in Schools and Colleges," Dr. Charles L. Reese, Chemical Director, E. L. du Pont de Nemours & Company.

Symposium, "Outstanding Problems of the Science Curriculum." (Ten-minutes papers.)

"The Present Status of Science in the High Schools of New York City," Rosemary F. Mullen, Chairman of Science Dept., Washington Irving High School, New York City.

"The Ideal Science Curriculum for the High School," J. M. Arthur, Science Master, Tome School, Port Deposit, Md.

"The Elective System and the Science Curriculum in the Secondary School," Henry M. Snyder, Head of Science Dept., Wilmington High School, Wilmington, Del.

"Biology in the Science Curriculum," Winifred J. Robinson, Dean of Women's College, Univ. of Del., Newark, Del.

"The Status of the American Chemical Society on the Correlation of High School and College Chemistry," Neil E. Gordon, Head of Chemistry Dept., Univ. of Maryland, College Park, Maryland, Secretary of Chemical Education Section, American Chemical Society.

Address, "The Relation Between Science and Modern Religious Thought," Dr. S. C. Schmucker, Professor of Biology, State Normal School, West Chester, Pa.

THE MISSOURI RIVER

The Missouri is one of the great drainage channels of the United States, measuring in total length about 2,400 miles. According to the United States Geological Survey, Department of the Interior, it drains 527,155 square miles, a territory as great as that embraced in all the States south of New York and east of the Mississippi, except Indiana and Illinois.

Although the Missouri is no longer utilized to any extent as a means of communication and transportation, it is destined to play a large part in the development of its drainage basin by furnishing water for irrigation and generating power.

NITRATES IN SOUTHEASTERN CALIFORNIA

Nitrogen is needed in large quantities for use in fertilizers, in explosives required in engineering and mining, and in munitions made for national defense in war. During the World War the demand for nitrates became so urgent that every known source of them in the United States was ransacked to find enough to supply our ever-increasing needs. The world's storehouse for nitrates is Chile, but the growing menace of the submarine made it imperative to divert to other uses the shipping then engaged in the Chile nitrate trade.

Small quantities of nitrates are found in almost every region where the rainfall is very small. The most promising deposits in the United States were those in the Amargosa region, in southeastern California. Before the war some of these deposits had been examined several times, chiefly by private companies that sought to obtain capital for their exploitation, but the reports made were so conflicting that the United States Geological Survey, Department of the Interior, decided to make a careful study of all the deposits in that region.

The nitrate-bearing material, or "caliche," as it is called in California, resembles in character and mode of occurrence the well-known caliche found in Chile, but is it much poorer and thinner. It forms a layer a few inches thick that lies less than a foot below the surface, at the plane of contact between the unaltered bedrock, wnich there consists chiefly of beds of Tertiary clay shale and the overlying clay soil. A white powdery layer, composed chiefly of sulphate of sodium and calcium, nearly everywhere lies between the caliche and the clay soil. The caliche cuts across successive tilted beds of the underlying clay shale and is thus clearly independent of the geologic structure.

In the examination made by the Geological Survey maps and cross sections were made at many places. Scores of trenches and hundreds of pits were dug down to or into the bedrock, and the soil, caliche, and bedrock were than systematically sampled. Many hundred qualitative tests and nearly a thousand qauntitative analyses of the caliche were made. The commercial development of the deposits, though they are the most promising in the country, was found to be impracticable, but the results of the investigation should set at rest any uncertainties as to the nature or quantity of the nitrates in the areas examined and should serve as a guide in the exploration of other supposedly nitrate-bearing regions.

An account of this investigation is given in the Geological Survey's Bulletin 724, on *Nitrate Deposits in the Amargosa Region, Southeastern California*, by L. F. Noble, G. R. Mansfield, and others.

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg.

Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

SOLUTION OF PROBLEMS.

751. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn, N. Y.*

Find the value of

$$\sin\left[2\cos^{-1}\left\{\tan\left(3\cot^{-1}x\right)\right\}\right]$$

Solution by Morris Monsky, student, Columbia College.

Let $\cot^{-1}x = a$. Then $\tan 3a = (3x^2-1)/(x^3-3x)$.

Let $\tan 3a = b$; $\cos^{-1}b = c$. Then $\sin 2c = 2\sin c\cos c = 2b\sqrt{(1-b^2)} = 2(3x^2-1)(x^6-15x^4+15x^2+1)^{1/2}/(x^3-3x)^2$.

Also solved by *T. P. Bugdanoff, Manchuria, China; Michael Goldberg, Philadelphia, Pa.; N. L. Roray, Metuchen, N. J.*

752. *Proposed by Walter R. Warne, Syracuse University, Syracuse, N. Y.*

The sum of n terms in two Arithmetic Progressions are respectively $n(n+1)$ and $\frac{1}{2}n(\frac{1}{2}n-1)$. Determine if they have a common term.

Solution by Nelson L. Roray, Metuchen, N. J.

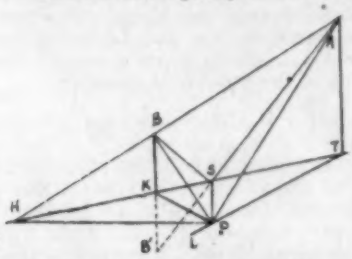
The first A. P. is evidently 2, 4, 6, 8..... and its nth term is $2n$. The second A. P. is $-1/4$, $1/4$, $3/4$, $5/4$, ... and its nth term is $n/2-3/4$ or $(2n-3)/4$ which is a fraction for all integral values of n. Hence each term of the first is an even integer, and each term of the second is a fraction. Therefore, there can be no common term.

Also solved by *Thomas E. N. Eaton, Redlands, Cal.*; *Michael Goldberg, Morris Monsky.* The two A. P. can be found in various ways. *T. E. N. Eaton* found them by comparing the sum $n(a+l)/2$, with $n(n+1)$, the given sum. *Michael Goldberg* found them as follows:

Substituting various values of n in $n(n+1)$ we get the series 0, 2, 6, 12, 20, 30, ... and the first differences 2, 4, 6, 8, 10 must be the A. P. of the problem. Similarly, $1/2n(1/2n-1)$ gives the series $0, -1/4, 0, 3/4, 2, 15/4,$ ..... and its first differences form the second A. P.

753. *Proposed by G. H. Crandall, Culver Military Academy, Culver, Ind.*

Given two points, A and B, on the same side of a plane, and at distances a and b from the plane. The distance between the projection of A and B on the plane is d. Find the locus of a point P on the plane such that the lines PA and PB are equally inclined to the plane.



Solution by Thomas E. N. Eaton, Redlands, Cal.

In the figure, AT and BK are $\perp$ to the plane. B′ is on the other side of the plane and BK+KB′. Join B′ to A. Then $\triangle$BKS sim. $\triangle$ATS, and KS/ST $= b/a$. Extend AB to intersect the plane at H. Then

$\triangle AHT$ sim. $\triangle$ BKH, and $HK/HT = b/a$. Hence $HK/HT = KS/ST$ so that KT is divided harmonically at H and S.

Let P be any point which obeys the law. Then $<APT = <BPK$ and $\triangle APT$ sim. $\triangle BPK$, so that

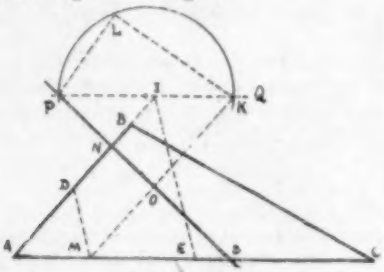
$PT/PK = a/b = ST/SK = HT/HK$.

Hence PS bisects $<KPT$, and PH bisects KPL. Therefore $<HPS = 90°$, and P is a point on a circle in the plane and drawn on HS as a diameter.

Similarly solved by *Nelson L. Roray*, who adds that the radius of the circle is $abd/(a^2-b^2)$ where d = KT. Using coordinates, the equation of the locus was derived by *T. P. Bugdanoff*; *M. Goldberg*; and *M. Monsky*, who adds further that if $a = b$, the locus is the perpendicular bisector of KT.

754. *Proposed by Smith D. Turner, Andover, Mass.*

Given $\triangle ABC$ and a point P outside the triangle. Required to draw a line through P bisecting the triangle.



Solution by C. E. Githens, Wheeling, W. Va.

Construction. Through P draw PQ || AC. Extend AB to meet PQ in I. D, E are the midpoints of AB, AC. Draw EI. Draw DM ll EI. Draw MK ll AI. Construct a semicircle on PK as a diameter. Make PL = PI. Draw LK. Make MS = LK. Join P to S, intersecting AB in N. Then PS is the required line.

Proof. Since triangles ADM and AIE are similar, $AM/AE = AD/AI$ or $AM \times AI = AD \times AE$. Multiply both members of this equation by sinA, and note that $AD \times AE \sin A = \frac{1}{2}\triangle ABC$, while $AM \times AI \sin A$ = area of AIKM. Then $AIKM = 1/2\triangle ABC$. Hence, we next prove that $AIKM = \triangle ANS$.

Since $\triangle$s POK and PNI are similar, $\triangle POK/\triangle PNI = PK^2/PI^2$ or $(\triangle POK - \triangle PNI)/\triangle POK = (PK^2-PI^2)/PK^2$, or

$IKON/\triangle POK = LK^2/PK^2 = MS^2/PK^2 = \triangle MOS/\triangle POK$.

$\therefore$ Quadrilateral IKON = $\triangle MOS$. If to the members of this equation we add the quadrilateral ANOM, we find that $AIKM = \triangle ANS$ which was required above.

Also solved by *Norman Anning, T. P. Bugdanoff, T. E. N. Eaton, Michael Goldberg, Morris Monsky* by deriving a quadratic equation whose coefficients were various lines in the figure. This problem is of frequent interest. It will be found as No. 558 (June, 1918) and also No. 343 (Nov. 1913), where *N. L. Roray* gives a rather simple geometric construction for the roots of the quadratic equation.

755. *For high school pupils.*

A goldsmith charged 2 per cent commission when purchasing some gold from A (meaning that A received only 98 per cent of the value of the gold), and 2 per cent when he sold the same gold to B (meaning that B paid 102 per cent of the value of the gold). But the goldsmith made an extra $25 in the deal by cheating, as he bought with a "pound" weight which actually weighed 17 oz., and sold with a "pound" weight which only weighed 15 oz. How much did A get for his gold?

Solution by Rene d'Urbal, Lewis and Clark High School, Spokane, Washington.

Let x = value of the gold. Then 98% of x is what A should receive; 98% of $16x/17$ is what he receives.

HISTORY OF CHEMISTRY

By FRANCIS P. VENABLE

A Brief History of the Development of the Science

The first four chapters trace the beginnings through the Dark Ages and through the Middle Ages. These are followed by an account of the discoveries which laid the foundations of modern chemistry. A chapter is devoted to each of the following topics: Atomic Theory, Atomic Weights, the Nature of the Elementary Atom, Affinity, and Growth of Inorganic Chemistry. The most significant part of the book is represented by the last five chapters on the development of Organic Chemistry, Theories as to Structure, Physical Chemistry, Bio-Chemistry, and Radioactivity.

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SILVER ORE IN THE SAN JUAN MOUNTAINS.

One of the most interesting mining regions in the United States scenically, historically, and geologically, is that including the San Juan Mountains, in southwestern Colorado, which contains Silverton, Telluride, Ouray, Rico, and other mining towns. In these mountains are Camp Bird, Smuggler-Union, Liberty Bell, Tomboy, Yankee Girl, Sunnyside, Silver Lake, Enterprise, and other well-known gold and silver mines, some of which have yielded also much lead.

Many of the ores of the San Juan Mountains contain minerals that are rich in silver, and the question has often been asked, "Were these minerals formed by water that, percolating downward, collected the silver from the upper part of the vein and redeposited it at a lower level, or were they formed by the hot ascending waters from which the ores were originally deposited?" If formed by the first process, the rich silver ores would represent the downward enrichment of a comparatively low-grade vein and would be confined to its upper part. If formed by the second process, the rich silver minerals might continue to as great a depth as any other of the ore minerals.

It was, therefore, important to determine, if possible, the process by which the rich silver-bearing minerals were formed. This problem was studied by E. S. Bastin, of the United States Geological Survey, whose report has recently appeared as Bulletin 735-D, "Silver enrichment in the San Juan Mountains, Colorado," and can be obtained by applying to the Director, U. S. Geological Survey, Washington, D. C.

Mr. Bastin finds by microscopical and chemical study of the ores that, though some of them were formed by downward enrichment, others were deposited originally in the vein and may therefore occur at depths far below the bottom limit of enrichment. This discovery is decidedly encouraging to the future operation of some of the mines.

The Central Association of Science and Mathematics Teachers meets at the Hyde Park High School, Chicago December 1 and 2. Be sure to be there.

The goldsmith cheated A out of $x/17$ ounces, but he also cheated himself out of a 2% commission on $x/17$ ounces because the goldsmith would have received a greater commission if he had weighed honestly. Hence the goldsmith's profit through this fraud was $x/17-2/100\,x/17$ or $98x/1700$.

Since B bought the same gold he paid for $16x/15$. The goldsmith charged for $x/15$ ounces which he did not sell and even charged a 2% commission on these $x/15$ ounces. Hence the profit in this fraud was $x/15+(2/100)x/15$ or $102x/1500$. Then

$$98x/1700 + 102x/1500 = 25,$$

or $x = 2500\times17\times15/(15\times98+17\times102)$

$= 2500\times255/3204$

A received 98% of $16x/17$ or \$183.51.

The editor has frequently used this problem in the mathematics clubs of the high school pupils. It is just annoying enough to make a bright pupil work. The most frequent error is that of not seeing that the goldsmith cheats himself out of a part of his commission when he buys from A. We can also separate the brightest pupil from the bright ones by seeing who finds the value of x in dollars and cents and who merely substitutes the fractional value of x into 98% of $16x/17$. Also, the quantity $15\times98 + 17\times102$ may be easily evaluated by writing it as $(16-1)(100-2)+(16+1)(100+2)$. Furthermore, the problem can be solved by arithmetic without the use of x or an equation. *A. M. Waas, Philadelphia, Pa.*, also suggests that gold bricks are weighed 12 ounces to the pound, not 16.

PROBLEMS FOR SOLUTION.

766. *Proposed by Norman Anning, Ann Arbor, Mich.*

The plan of the Bahai Temple in Wilmette, Ill., is a regular nonagon. If the length of a side is 70 feet, what is the greatest distance from a side at which a person can stand (outside the temple) and see just one side? just two sides? just three sides?

767. *Proposed by James Singer, Cornell '26.*

Prove that cos 36° is a root of the equation $4x^3+2x^2-3x-1 = 0$

The following problem is different from any hitherto proposed in the department:

768. *Proposed by F. A. Cadwell, St. Paul, Minn.*

Given $\triangle ABC$. *State in the fewest possible words* (two letters denoting a line to count as one word) how to find a point, P, on AC produced such that if a line be drawn through P parallel to BC and meeting AB produced in D, the $\triangle CPD$ will equal $\triangle ABC$ in area.

769. *Proposed by Morris Monsky, student Columbia College.*

Find the ratio of the number of acute triangles possible to the number of obtuse triangles; and show that the ratio is approximately 7 to 13.

770. *For high school pupils. Proposed by the Editor.*

Prove in as many ways as you can:

In $\triangle ABC$, the side AC is twice the side AB. Prove that $\angle B$ is greater than twice $\angle C$.

For the benefit of new readers of this department, the following announcement from October, 1920, is repeated: the last problem each month is intended for pupils. By proposing the problem in a class or mathematics club, an added interest in the subject may be stimulated among some of the pupils. Teachers are invited to suggest problems of of interest. The results are frequently of direct benefit to all of us. The proofs of problem 740, for example, in the June number are better than many found in text-books. Further, after the pupil has solved the above problem, a discussion of the article on *Geometrical Analysis* in this issue would lend additional interest to the subject.

Note: If *J. G. Yelland* will forward his address, the editor can answer his letter.

Stories for Speakers

THE KABLEGRAM, which is a fun-loving fraternal review, publishes a page of funny stories for speakers each month. It has other interesting features for fraternalists. Send 50 cents for a year's subscription (or a dollar bill for three years) to *The Kablegram* Mt. Morris, Ill.

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AN EXAMPLE IN GEOMETRICAL ANALYSIS.[1]

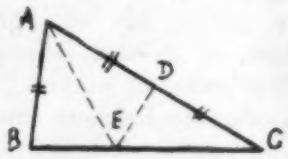
By Professor J. T. Crawford,
Ontario College of Education, University of Toronto.

When an original exercise in geometry is to be solved, the most powerful weapon at the command of the pupil is analysis. It often happens that an exercise can be analysed in a variety of ways and it is interesting to examine if each of these methods of analysis will lead to a solution of the problem. Take the following as an illustration.

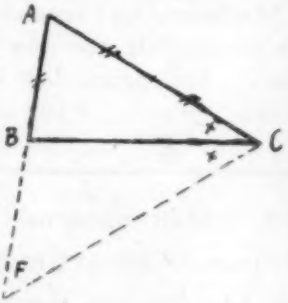
In the triangle ABC (fig. 1), the side AC is twice the side AB; show that the angle B is greater than twice the angle C.

We are here required to prove an inequality—that one angle is greater than twice another angle. Now there is no theorem that does this directly, so we must vary the conclusion required to make it conform to ome theorem already proven. This may be done in a number of ways.

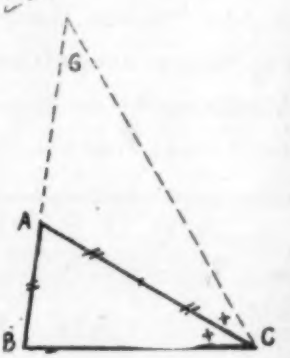
(1) Use the fact that the exterior vertical angle of an isosceles triangle is double either base angle. Bisect AC (fig. 1) at D and draw DE perpendicular to AC meeting BC at E. Now angle AEB is twice angle C. If we can now prove angle B greater than angle AEB, or AE greater than AB, the conclusion required will follow. Can this be done?



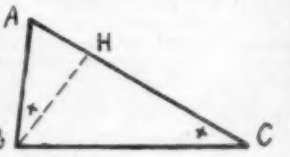
(2) If we double the angle C (fig. 2) by making angle BCF equal to angle C, we must prove that angle BFC is greater than angle C, or BC greater than BF. Can this be done?



(3) If we double the angle C (fig. 3) by making angle ACG equal to angle C, we must now prove angle B greater than angle BCG, or CG greater than BG. Can this be done?



(4) From angle B (fig. 4) cut off angle ABH equal to angle C. Can we now prove that angle HBC is greater than angle C?



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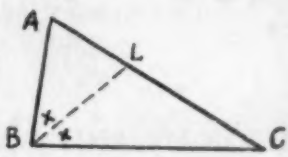
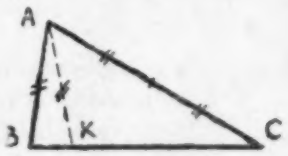
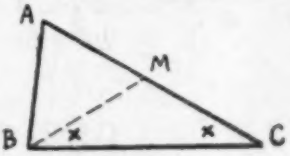
(5) If we make such a change that angle B (fig. 5) becomes an exterior angle of a triangle in which angle C is an interior angle, we could then express the angle B in terms of angle C. With the centre A and radius AB describe a circle cutting BC at K. We must now prove angle KAC greater than angle C. Can this be done?



(6) Draw BL (fig. 6) to bisect angle B. Can we now prove that angle LBC is greater than angle C?



(7) Make angle CBM (fig. 7) equal to angle C. Can we now prove angle ABM greater than angle C? What is the conclusion when angle ABC is a right angle; when it is an obtuse angle?



(8) Can we prove it trigonometrically by showing that sin B is greater than sin $2C$?

These are not all the possible methods of attack, but they are sufficient to show that the pupil who is not successful with the first method he has tried should not therefore assume that he cannot solve the exercise.

Note concerning the preceding article on geometrical analysis. If any teacher wishes reprints of this article for use in their classes, such reprints may be obtained from the publishers at the rate of $1.50 per 100, or 80 cents for 50, postpaid. See also problem 760 in the Problem Department.

THE NEW CHAIRMAN OF THE DEPARTMENT OF GEOLOGY AT THE UNIVERSITY OF CHICAGO

Dr. Edson Sunderland Bastin, Professor of Economic Geology in the University of Chicago, has been made Chairman of the Department to succeed the late head, Dean Rollin D. Salisbury, according to a recent announcement of the Board of Trustees. Professor Bastin, who for fifteen years was geologist in the United States Geological Survey and was recently chief of the Division of Mineral Resources, received both his Master's and Doctor's degrees at the University of Chicago. He has done special work for the government in Maine and the western mining districts, made an examination of copper properties in Chile, and is the author of numerous scientific reports published by the United States Geological Survey.

It is a matter of special interest that Professor Bastin's father was a professor in the Old University of Chicago.

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From Tennessee, in a letter by J. M. Breckenridge, Director Dept. of Chemistry of Vanderbilt University, Nashville, come these expressions:

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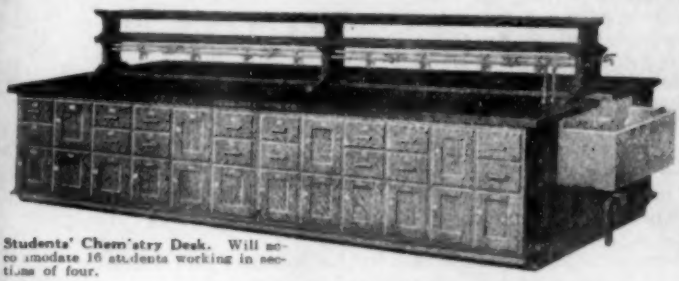

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NEW DEAN OF THE OGDEN GRADUATE SCHOOL OF SCIENCE UNIVERSITY OF CHICAGO

Announcement is just made by the University of Chicago Board of Trustees of the appointment of Professor Henry Gordon Gale, of the Department of Physics, to be Dean of the Ogden Graduate School of Science, to succeed the late Dean Rollin D. Salisbury, who occupied the position for over twenty years. Professor Gale, who has been Dean in the College of Science for ten years, received both his Bachelor's and Doctor's degrees from the University and has been connected with the Department of Physics since 1899. He has been physicist and research associate of the Carnegie Institution of Washington at Mount Wilson, California, joint editor of the *Astrophysical Journal* for ten years, member of the International Commission on Annual Tables of Constants, and chairman of the Division of Physical Sciences, National Research Council.

During the war Dean Gale was major and lieutenant colonel in the Signal Corps and was an officer in charge of a special service division at Tours, France. He was cited by the commander-in-chief of the American Expeditionary Forces for "especially meritorious and conspicuous service," and has recently received the decoration of the Chevalier of the Legion of Honor.

SCIENCE QUESTIONS.

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Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E. Cleveland, Ohio.

The EDITOR will receive examination papers with many thanks. School examinations of all sorts are desired. Please send them in—likewise any newspaper clippings similar to the question proposed in this issue.

PROBLEMS AND QUESTIONS FOR SOLUTION.

399. A motor truck hauls a 43-ton boiler six city blocks. A 5-ton truck carries a capacity load over an ordinary country road.

Which machine is performing the greater "stunt"?

(*a*) Adopt reasonable figures for road and load resistances and compare numerically.

(*b*) What apparatus would an engineer require to make an experimental comparison?

EXAMINATION PAPERS.

400. *The following paper was submitted by Mr. John Lundberg, Goteborg, Sweden. Translation by Mr. Olle Schjolin, (Graduate Orebro Tekn. Elem. Skola, Orebro, Sweden. Designer, The White Motor Co.*

Sweden — STUDENT-EXAMEN — PROBLEMS IN PHYSICS

April, 1922.

1. In a mercury manometer with one leg closed and the chamber filled with dry air when the pressure is 760 mm. at a certain temperature, the mercury level in both legs stands at the same height. The volume of the enclosed air is then 50 cc. The manometer tube which stands vertically has an area of 1 sq. cm.

Now, if the open leg is filled with water to a height of 48 cm. and also the pressure over this leg is changed, what must be the pressure to make the level of mercury in the closed leg 10 cm. higher than in the open leg?

(The temperature remains constant. Sp. gr. mercury 13.6)

2. A straight solid stick of any area is placed on end on a horizontal floor leaning against a wall in a vertical plane at right angles to the wall. The stick is in equilibrium at a very small angle because of friction;

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but, if the angle is made larger, the friction is at last overcome and the stick begins to slide.

Find the angle at which the stick starts to slide.

The coefficient of sliding friction against the wall is cw and against the floor is cf.

3. An equal arm scale has a closed glass bulb of outside volume 300 c.c. on one fan and a 40 grm. brass weight in the other. The scale is in balance in dry air at 18° Celsius and an air pressure of 760 m.m.

If the scale is placed in hydrogen at the same temperature and pressure, it is necessary to add 333 mgm. to the pan with the brass weight in order to maintain static balance.

The weight of 1 litre of dry air at 18° Celsius and 760 mm. is 1.213 gm.

Find the weight of 1 litre of hydrogen at the given temperature and pressure. The specific gravity of brass is 8.3.

4. An electric water distillation apparatus consumes 4.5 amperes when connected to a circuit in which the electrical pressure is 220 volts. The distilled water is replaced with water at 15° Celsius in such a way as to keep the volume of water in the apparatus constant. With continuous distillation 1.1 kgm. of water per hour is distilled.

What per cent of the electrical energy consumed is useful in the distillation?

The heat of vaporization of water is 536. A current of 1 amp. gives 0.24 gram-calories per second in a circuit with a resistance of 1 ohm.

5. On a test tube 12 cm. deep, filled to the brim with water, is placed a thin plano-convex lens so that the flat side of the lens touches the water surface.

The radius of the convex lens surface is 4 cm. and the refractive index of the glass is 3/2. Where will the image of a piece placed on the bottom of the test tube fall.

The index of refraction for water is 4/3.

6. Of two galvanic batteries one has an electromotive force of 1.5 volts and internal resistance of 3.2 ohms, and the other has an electromotive force of 1.2 volts and an internal resistance of 0.7 ohm.

Each circuit is closed by a wire but the resistance in these wires has to be adjusted so that the current in both circuits is the same and so also that the heat which is developed during the same time is the same in both external circuits.

What is the resistance in the two wires?

7. Two batteries, with electromotive forces of 20 and 24 volts and resistances of 2.8 and 4.2 ohms respectively, are connected in paralled by a wire with a resistance of 54 ohms.

How strong is the current which passes through each battery? "

8. Tell the important characteristics observed in the two different kinds of transverse wave motions—the running and the stationary waves.

SOLUTIONS AND ANSWERS.

From Problems in Physics, Swedish Student-Examen., 1921.

384. A chain of length l is placed on an inclined plane and is in equilibrium. One part of the chain is resting on the plane while the remainder is allowed to hang freely over the edge.

Give the longest and shortest part of the chain which can rest on the plane.

The angle of the plane with the horizontal is $V°$ and the coefficient of friction C.

Solution by Mr. John Lundberg. Translated into English by Mr. Schjölin.

Call the length of the chain which lies on the plane x cm. and the weight of 1 cm. of the chain p gm.

Then the force acting from B toward A is

$$R_1 = px \sin V$$

And the force acting from B toward C is

$$R_2 = p(l - x)$$

The friction is $f = cpx \cos V$ (c is the coefficient of friction)

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$$\text{and } x = 1/(\sin v + 1 - e \cos v)$$
When the chain starts to slide toward C
$$px \sin V = p(1-x) - epx \cos V$$
$$\text{and } x = 1/(\sin v + 1 + e \cos v)$$
Hence, the maximum length is $1/(1+\sin V - e \cos V)$
And the minimum length is $1/(1+\sin V + e \cos V)$

From the same examination. No.3.

An organ pipe gives a certain tone at 0°. How much must the temperature rise to raise the pitch one-half tone?

The speed of sound in air is proportional to the square root of the absolute temperature of the air. One-half tone is an interval of 16/15. Absolute zero is at −273° C. Temperature expansion of the pipe is not to be considered.

Solution by Mr. Lundberg.

Call the temperature $t°$ (Celsius!)

n_t and n_o are the two vibration numbers at $t°$ and $o°$.

h_t and h_o are the speeds of sound at $t°$ and $o°$.

Then $n_t = h_t/\lambda$, and $n_o = h_o/\lambda$; therefore $n_t/n_o = h_t/h_o$

but $n_t/n_o = 16/15$; therefore $h_t/h_o = 16/15$

but, if $T = 273+t$ Then $h_t/h_o = \sqrt{T/273}$

Hence, $16/15 = \sqrt{T/273}$ and $T = 256/225 \cdot 273 = 310.6$

and $t = T - 273 = 37.6°$.

Therefore the temperature is 37.6°.

386. *From the same examination.*

A glass ball, whose cubical coefficient of expansion is .000024, weighs in air 90 gm. If it is put into a certain liquid the temperature of which is 12°, it weighs then 49.6 gm. If the liquid is heated to 97°, the weight of the glass ball will be 51.9 gm. What is the coefficient of expansion of the liquid?

Solution by Mr. John Lundberg.

The volume of the ball is v_1, and v_2 at 12° and 97°.

The specific gravity of the liquid is s_1 and s_2 at 12° and 97°.

Call the expansion coefficient for the liquid x and for the glass g.

Then $v_1 s_1 = 90 - 49.6 = 40.4$

$v_2 s_2 = 90 - 51.9 = 38.1$

but $v_2 s_2 = v_o s_o (1+97g)/1+97x$

and $v_1 s_1 = v_o s_o (1+12g)/1+12x$

Hence, $1+97g/1+12g \quad 1+12x/1+97x = 38.1/40.4$

$1+97x/1+12x = 40.4/38.1 = 1.002328/1.000288 = 1.0625$

Therefore $x = 0.0007418$

Answer: The coefficient of expansion for the liquid is 0.0007418.

PHYSICS IN SWEDEN.

BY JOHN LUNDBERG,

Högre-real-läroverket, Göteborg, Sweden

[The following is an extract from a letter to Franklin T. Jones, Editor of the Science Questions Department. It contains information which will prove very interesting to all students of the science situation in American schools. F. T. J.]

Perhaps it may interest you to hear something about the organization of the teaching of physics at our state schools. The boy (or girl) enters this sort of school at 9-10 years of age. Physics begins with the fourth year with 2 "hours" per week (the "hour" being always 45 minutes) plus 1 laboratory of two hours every other week (the school year = 39 weeks), the course being statics and heat. In the fifth year there is only 1 hour per week plus 1 laboratory of two hours every other week. The course is magnetism and electricity.

With the beginning of the sixth year, the pupil enters the "gym-

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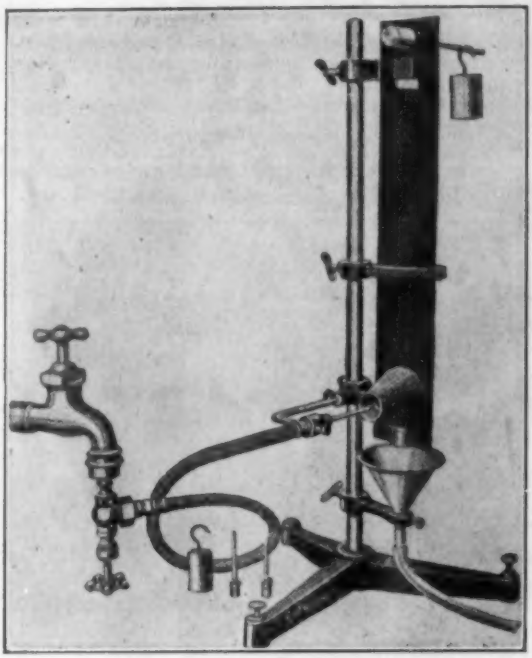

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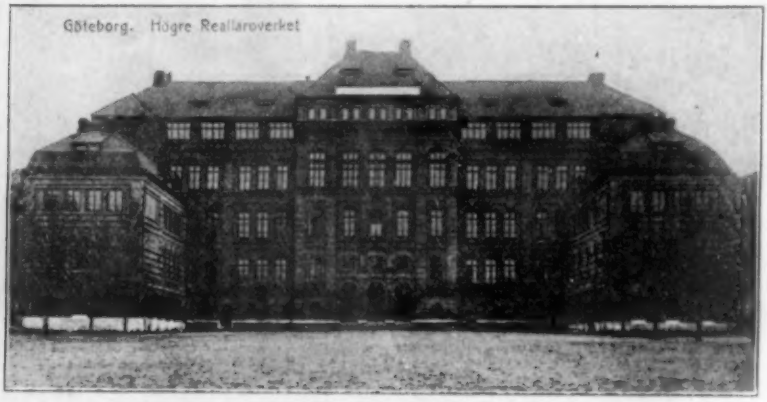
nasium" the forms of which are called "first ring", "second ring" etc. In the Latin-gymnasium they are taught Latin and Greek, but less mathematics and physics and no chemistry. In the Real-gymnasium there is no Latin or Greek but more importance is attached to mathematics, physics and chemistry. The physics courses of this real gymnasium are as follows:

Ring 1. (3 hours per week) *Statics* (wider course than in the 4th year) The most important laws of dynamics, a little astronomy.

Ring 2. (2 hours per week plus 1 laboratory of 2 hours every month.) Heat, magnetism, electrostatics.

Ring 3. (4 hours per week plus 1 laboratory of 2 hours every month.) Electrodynamics, Acoustics, Optics (partly).

Ring 4. (3 hours per week plus 1 laboratory of 2 hours every month during the fall terms.) The rest of optics dynamics, repetition of the whole gymnasium curriculum.



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The *student examination* consists of written and oral tests. On the real gymnasium there are written tests in Swedish, Mathematics, English, German and physics. Each test has its day, hence physics is "5th day of writing," there being always one day free between every two days of writing. These tests are in the middle of April. About one month to six weeks later come the oral tests in all the disciplines which are taught in the 4th ring, there being specially elected university professors (called "censors") going from school to school in groups of three and determining for every discipline on what chapter the teacher must examine, this order being given just immediately before the examination in which that discipline is to take place, so that neither teacher nor pupils can know anything about it before. So you see there is a little excitement in it. The Censors attend to the examination, and afterwards they decide if a pupil is to be approbated or not.

At most state schools there are both Latin and real gymnasia. But in Stockholm and Göteborg the two greatest cities, there are schools with one line only. So here in Göteborg we have one school of each sort, the Högre-Lätinläroverket with about 800 pupils and the Högre Real-läroverket with about 700 pupils. Besides these "higher schools" with gymnasium (these are all for boys only) there are in many places schools with only six forms, leading to a lower examination, the "real-skolexamen." The sixth form in those schools has its own curriculum, which is not the same as in the first ring. Here in Göteborg are two schools of this sort, each with about 500 pupils. For the matriculation at a university you must have passed the "studentexamen" and this examination is in the common mind considered a sign of higher education, those having passed it belonging thereby to the higher social layer. So the white velvet cap, that marks the "student" is highly strived for and there is much poetry about it.

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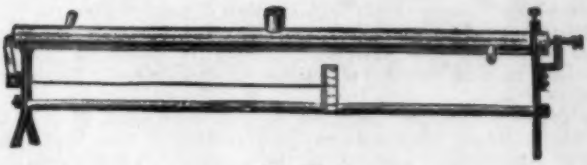

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ARTICLES IN CURRENT PERIODICALS.

American Botanist, for August, *Joliet, Ill.*, $1.50 *per year*, 40 *cents a copy*. "Old Garden Flowers," "Gardening in an Artificial Bog," Henry Bird; "Botany for Beginners," Willard N. Clute; "Important Movements of Plants," John J. Birch; "Plant Names and Their Meanings," Willard N. Clute.

American Journal of Botany, for October, *Brooklyn Botanic Garden, Brooklyn, N. Y.*, $6.00 *per year*, 75 *cents a copy*. "Studies of the Mechanism of the Physiogical Effects of Certain Mineral Salts in Altering the Ratio of Top Growth to Root Growth in Seed Plants," Thomas W. Turner; "A Preliminary Notice of Genetical Studies of Resistance to Mildew in Oenothera," Peter J. Klaphaak and H. H. Bartlett; "Growth of Some Parasitic Fungi in Synthetic Culture Media," H. C. Young and C. W. Bennett.

American Mathematical Monthly, for March, *Lancaster, Pa.*, $4.00 *per year*, 45 *cents a copy*. "Sixth Annual Meeting of the Mathematical Association of America," Professor W. D. Cairns; "Serret's Analogue of Desargue's Theorem," Professor H. S. White; "A Certain Two-Dimensional Locus," Dr. J. L. Walsh; "Among My Autographs: 20. Babbage Visits Mme. Laplace; 21. DeMorgan and the Libri Controversy," Professor D. E. Smith; Questions and Discussions.

Condor, for September-October, 770 *South Pasadena Ave., Pasadena, Calif.*, $2.00 *per year*, 40 *cents a copy*. "The Mimetic Aspect of the Mocker's Song" (with four photos) Donald R. Dickey; "Our English Nomenclature," A. D. Dubois; "Cactus Wrens' Nests in Southern Arizona," Florence Merriam Bailey; "Notes on the Summer Avifauna of Bird Island, Texas, and Vicinity" (with seven illustrations), Alvin R. Cahn.

Education, for September, 120 *Boylston Street, Boston*, $4.00 *per year*, 40 *cents a copy*. "Adolescence," Jospehine Weatherly; "A New Kind of Rural School," Lloyd Rogers; "How the Superintendent May Improve the Teaching," R. C. Clark; "Introducing Virgil to the Blacksmith," John Hampton Atkinson; "Gambling from a Teacher's Standpoint," John J. Birch.

Journal of Geography, for September, 2249 *Calumet Ave., Chicago*, $2.00 *per year*, 25 *cents a copy*. "Geographic Factors Affecting the Growth of American Cities—A Synopsis," R. H. Whitbeck; "New York," John W. Frey; "Philadelphia," Ralph H. Brown; "Cleveland," George E. Wood, "Cincinnati," J. R. Whitaker; "The Twin Cities," Earl D. Brown; "St. Louis," Elmer J. Johnson; "Seattle," Guy H. Smith.

Nature-Study Review, for October, *Ithaca, New York*, $1.50 *per year*, 20 *cents a copy*. "Conservation and Nature Studies," R. W. Shufeldt; "The Yellow Lady's Slipper," Clara Thomas; "Wild Flower Preservation Society of America," "The Mole," Adeline Wenger; "Society for the Preservation of New England Plants"; "The Pine," Henry Klein.

Photo-Era, for October, 367 *Boylston St., Boston*, $2.50 *per year*, 25 *cents a copy*. "Something about Photographic Bookplates," Dr. James E. Horning; "How Pyro is Obtained," Kodakery; "Trees that Shed their Bark," H. P. Webb; "Lantern-Slides and Stereo-Positives," Roy L. Cline; "Some Easy Lessons in Composition," William S. Davis; "A Removable Kit for the Printing-Frame," A. D. DuBois; "The Sad Experience of an Autochromist," Wilfred A. French; "Will Photo Research Upset the Theory of Light?", Studio-Light; "Drawing and Painting Self-Taught," Anson K. Cross.

Popular Astronomy, for October, *Northfield, Minn.*, $4.00 *per year*, 45 *cents a copy*. "Second Meeting of the International Astronomical Union in Rome, May 2-10, 1922," with Plates XXVI-XXVIII, O. J. Lee; "Drawings of Mars and Jupiter," with Plate XXIX, D. W. Morehouse; "Planetary Configurations," Frederic R. Honey; "The New International Symbols for the Constellations," Henry Norris Russell; "Formulae for Calculating Ephemerides of the Minima of Algol," William A. Mason; "Why I Would Take up Astronomy as a Profession," Rufus O. Suter, Jr.; "A Century Since the Great Herschel," Maynard Shipley; "Gravitation III," William H. Pickering; "Twenty-Eighth Meeting of the American Astronomical Society."

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School Review, for October, *University of Chicago Press*, $2.50 *per year*, 30 *cents a copy*. "The Junior College," George F. Zook; "A Social-Science Core for the Junior and the Senior High School Curriculum," Thomas Warrington Gosling; "The Teacher's School Week," John T. Greenan; "The Principal and the Small High School," A. H. Horrall; "Experiments in Social Education," Jessie E. Gibson; "Learning How to Teach from the Experience of a Student," Henry P. McLaughlin.

Scientific Monthly, for October, *Garrison, N. Y.*, $5.00 *per year*, 50 *cents a copy*. "The Conservation and Proper Utilization of Our Natural Resources," Barton W. Evermann; "Some Thoughts on Immigration Restriction," Robert DeC. Ward; "Social Life Among the Insects," William M. Wheeler; "The Path as a Factor in Human Evolution," Ralph E. Danforth; "Why Do We Laugh?," Wilson D. Wallis; "Some Problems of Progress," H. M. Dadourian; "Bacot, A Martyr to Science," Arthur H. Smith; "Modern Study of the Atom," Alan W. C. Menzies.

Toneya, for September-October, *Toney Botanical Club*, 8 *West King St., Lancaster, Pa.*, $1.00 *per year*, 30 *cents a copy*. "Austrian Field Cress," Albert A. Hansen; "Some Overlooked Scrophulariaceae of Rafinesque," Francis W. Pennel.

BOOKS RECEIVED

Prints of Human Geography, by Ellsworth Huntington, Yale University, and Sumner W. Cushing, Normal School, Salem, Mass. Pages XIV + 430. 16x24½ cm. 1922. Cloth. $3.50. John Wiley and Sons, New York City.

An Introduction to the Graphic Language, by G. C. Anthony, Tufts College. Pages VII + 166. 16x20 cm. Cloth. 1922. D. C. Heath & Co., Chicago.

The Expert Typist, Clarence C. Smith, Washington Business High School. Pages XIII + 274. 14x20½ cm. Cloth. 1922. Macmillan Co., New York.

Live Stock and Farm Mechanics, by John H. Gehrs, Missouri State Teachers' College. Pages VIII + 393. 14½x19 cm. Cloth. 1922. Macmillan Co., New York.

Industrial Physics, Mechanics, by L. R. Smith, Dickinson High School, Jersey City. Pages XI + 226. 13x19½ cm. Cloth. 1922. McGraw-Hill Book Co., New York City.

Problems in American Democracy, by Thames R. Williamson, Smith College. Pages XV + 567. 14½x20 cm. Cloth. 1922. D. C. Heath & Co., New York City.

Junior High School Mathematics, by E. H. Taylor, and Fiske Allen, Eastern Illinois Normal School. Pages X + 149. 13x19½ cm. Cloth. 1922. Henry Holt & Co., New York City.

Forty Notifiable Diseases, by Hiram Byrd, University of Alabama. Pages V + 74. 13x18½ cm. Paper. 1922. 60c. World Book Company, Yonkers, New York.

Fector Calculus, with Applications to Physics, by James P. Shaw, University of Illinois. Pages V + 314. 14½x20½ cm. Cloth. 1922. $3.50 net. D. Van Nostrand Company, New York City.

Elements of Astronomy, by D. N. Mallick, Fellow of the Calcutta University. Pages VIII + 233. 15x22½ cm. Cloth. 1921. Cambridge University Press.

Farm Projects for the Seventh and Eighth Grades, by Carl Calvin, and John A. Stevenson. Pages X + 363. 15x19 cm. Cloth. 1922. The Macmillan Company.

College Algebra, by Walter B. Ford, University of Michigan. Pages VII + 262. 13x19½ cm. Cloth. 1922. Macmillan Company.

Easy Experiments in Elementary Science by Herbert McKay. 144 pages. 12½x18½ cm. Cloth. 1922. 50c. Humphrey Milford, Oxford University Press, London, England.

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The Federal Board for Vocational Education, by W. S. Holt. Pages XI + 74. 15x23 cm. Cloth. 1922. D. Appleton & Company.

High School Geography, by R. H. Whitbeck, University of Wisconsin. Pages X + 577. 14½x20½ cm. Cloth. 1922. The Macmillan Company, New York.

Elements of Projective Geometry, by George H. Lin, George Wentworth, and David Smith. Pages VI + 186. 15x21½ cm. Cloth. 1922. $2.80. Ginn and Company, Boston.

The Smithsonian Institution Report for 1920. 704 pages. 16x23½ cm. Cloth. 1922. Government Printing Office, Washington.

General Mathematics, Book II, by William D. Reeve, University High School, University of Minnesota. Pages XII + 446. 14x19½ cm. Cloth. 1922. $1.60. Ginn & Company, Boston.

A Laboratory Outline of Smith's Intermediate Chemistry, by James Kendall, Columbia University. Pages IX + 127. 14x19½ cm. Cloth. 1922. Century Company, New York City.

Smith's Intermediate Chemistry, by James Kendall and Edwin E. Slosson, Columbia University. Pages XV + 566. 14x21 cm. Cloth. 1922. $3.25. The Century Company, New York City.

Training for Foreign Service, bulletin No. 27, Department of the Interior, Bureau of Education. Pages IV + 154. 15x23 cm. Paper. 1922. 15c. Government Printing Office, Washington.

The Professional Education of Teachers in Cleveland. IX + 92. 15x23 cm. 1922. Paper. Board of Education, Cleveland, Ohio.

High School and Sex Education, prepared under the direction of the surgeon general, United States Public Health Service; edited by Benjamin C. Gruenberg. Pages VII + 98. 15x23½ cm. Cloth. 1922. Government Printing Office, Washington, D. C.

BOOK REVIEWS

Farm Projects, by Carl Colvin, Supervisor of Agricultural Education in Illinois, and John A. Stevenson; pages X + 363. 14½x19 cm. Cloth. 1922. The Macmillan Company, New York City.

There are many people who attempt to teach agriculture in any old haphazard way. This is a book which endeavors to teach the teacher how to systematize his work and go from one subject to another in as nearly a correlated manner as it is possible for the subject of agriculture to be taught. Perhaps it is a book more than any other one that attempts to instill in the pupils' mind a love for his home and surroundings, thus causing him to keep the house and grounds in a very much more attractive way than he otherwise would. The book bears hard on the project method of tilling. I believe, however, that the principles of the project method should be thoroughly instilled before beginning the work.

Pupils will surely become interested in this text. It is intended for two years' work, there being twenty-three chapters for the first year and twenty-one for the second year. The book is mechanically well-made and will stand hard usage. Nearly every chapter closes with an outline of questions bearing upon the work just completed. The questions are practical and to the point.

There are sixty-eight figures scattered throughout the book.

C. H. S.

First Book in English for High Schools, by A. L. Murray, Normal School, Eau Claire, Wisconsin, and E. P. Wiles. Pages X + 478. 13x19 cms. Cloth, 1922. D. C. Heath and Co., Chicago.

This book deals with the problem of getting something to write about. With the problem of gathering and organizing material, and with the

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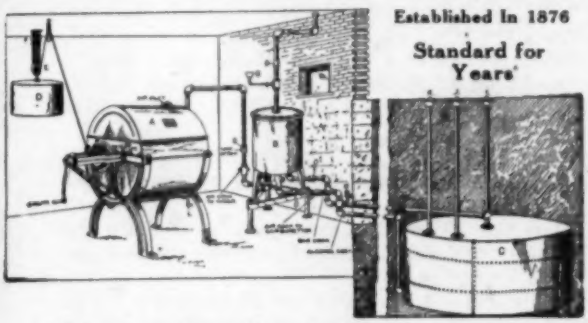

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problem of expressing thoughts clearly to definite readers or listeners. Several chapters are devoted to grammar to be used as the needs of a class demand. A concluding chapter gives organized material on the Better Speech Movement.

The book contains abundant models and subjects within the range of the high school pupil's experience. It stresses the importance of adapting the theme to the audience. It gives fundamental ideas and projects in newspaper writing. In short, it is a progressive book of real value.

The appearance of the printed page as an aid to clearness and emphasis deserves special commendation. Maxims of practice in heavy print serve to clinch basic ideas. The few illustrations are well chosen and ingeniously made the subjects for themes. This device might well have been used more freely.

Murray and Wiles First Book in English is an excellent text.

W. L. P.

Forty Notifiable Diseases, by H. Byrd, University of Alabama. Pages VI + 74. 13½x18½ cm. Paper. 1922. 60c. World Book Company, Yonkers-on-Hudson, N. Y.

This little text is a summary of the more important facts which should be possessed by every citizen. It sets forth those principles which the ordinary mind should assimilate.

The author is an experienced worker in these subjects and therefore knows absolutely how one should be directed in order to secure health after he has once lost it, and how to prevent his losing health which is the more important.

It is expressed in simple language, clear, and concise, and one without very much of the working knowledge of biology can readily understand.

High School and Sex Education, by Benjamin C. Gruenberg, United States Public Health Service. Pages VII + 98. 15x23½ cm. Cloth. 1922. Government Printing Office, Washington, D. C.

This is a splendid work and edited by a man who has spent many years in studying this subject. It is a clear presentation of the methods by which the teaching of this subject ought to be approached. It largely is a compilation of the ideas of the leading physicians and instructors who are interested in this phase of education. It is a book which all teachers of biology should possess as we believe instruction in sex education by any teacher will show marked increase in efficiency if the ideas contained in this text are put into operation.

References to other texts are given at the close of each chapter. Splendid outlines of courses are given in the appendix. It is a book which deserves and doubtless will have a wide circulation. C. H. S.

Industrial Physics, Mechanics, by L. R. Smith, Dickinson High School, Jersey City. Pages XI + 226. 13½x19½ cm. Cloth. 1922. McGraw-Hill Book Company, New York.

A book somewhat unique in its general makeup, yet to the point and well worth consideration for adoption in the laboratory by any teacher of physics.

The material presented is that which has been largely used by the author in his classes. Some of the older classical experiments and discussions have been omitted.

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trigonometry. Very few errors are noted. The proofreading has been well done.

The paragraphs are numbered consecutively and the main paragraphs begin with bold-faced type.

It is a book that no teacher in physics can be without. Mechanically, it is splendidly bound. C. H. S.

An Introduction to the Graphic Language, by Gardner C. Anthony, Tufts College. Pages VII + 166. 15½x20 cm. Cloth. 1922. D. C. Heath & Company, Boston.

Very few texts of this nature have ever come from the press. In this day and age it is often very difficult for the layman to understand what the author is driving at, due to the fact that he has no knowledge of mechanical drawings or graphs.

The function of this book is to make clear the nature of the drawings of various kinds and to help the reader to understand them clearly. There are within the body of the book 192 drawings, selected wisely for the thing they are to illustrate. The descriptive matter is clearly stated.

There are eight chapters, nearly every one closing with a set of questions and projects based upon the matter discussed in that chapter. Major paragraphs all begin with bold-faced type, they giving the key to the matter to be discussed in that paragraph.

There are various vocabularies of standard drawings given in an appendix. The book is completely indexed. Mechanically, it is well made and printed on calendered paper. It is a book that should be in the hands of everyone who wishes to become thoroughly familiar with graphs. C. H. S.

Live Stock and Farm Mechanics, by John H. Gehrs, Missouri State Teachers College. Pages VIII + 393. 14x19 cm. Paper. 1922. The Macmillan Company, New York.

There is no end at present of texts relating to agriculture. This, however, is one from the pen of a man who is thoroughly conversant with all matters appertaining to farm life. He has produced a book which makes interesting reading to any person interested in farm work.

It treats of most every important phase of farm work, such as the use of concrete, road making, rope tying, building, farming conveniences, boys' and girls' clubs, marketing, and many other things too numerous to mention.

The diction is splendid, the statements accurate, and altogether it is a very valuable text. There are 164 drawings and half-tones all selected for their worth in better explaining the text.

The book is divided into two parts of twenty-five chapters, most chapters ending with questions and projects that have been discussed. It is a book well worth while for every farmer and person interested in farm projects to possess. C. H. S.

The Federal Board for Vocational Education, by W. S. Holt. 15x23 cm. Cloth. 1922. D. Appleton & Co.

A valuable book for those who are interested in vocational education. There is a short history of this phase of education given, which is to the point and contains all of the high phases of vocational history. There is a chapter on organization, something to say with reference to the vocational board of education, and it has a summary of the publications of this department, and also an outline of the laws passed by Congress on the subject.

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